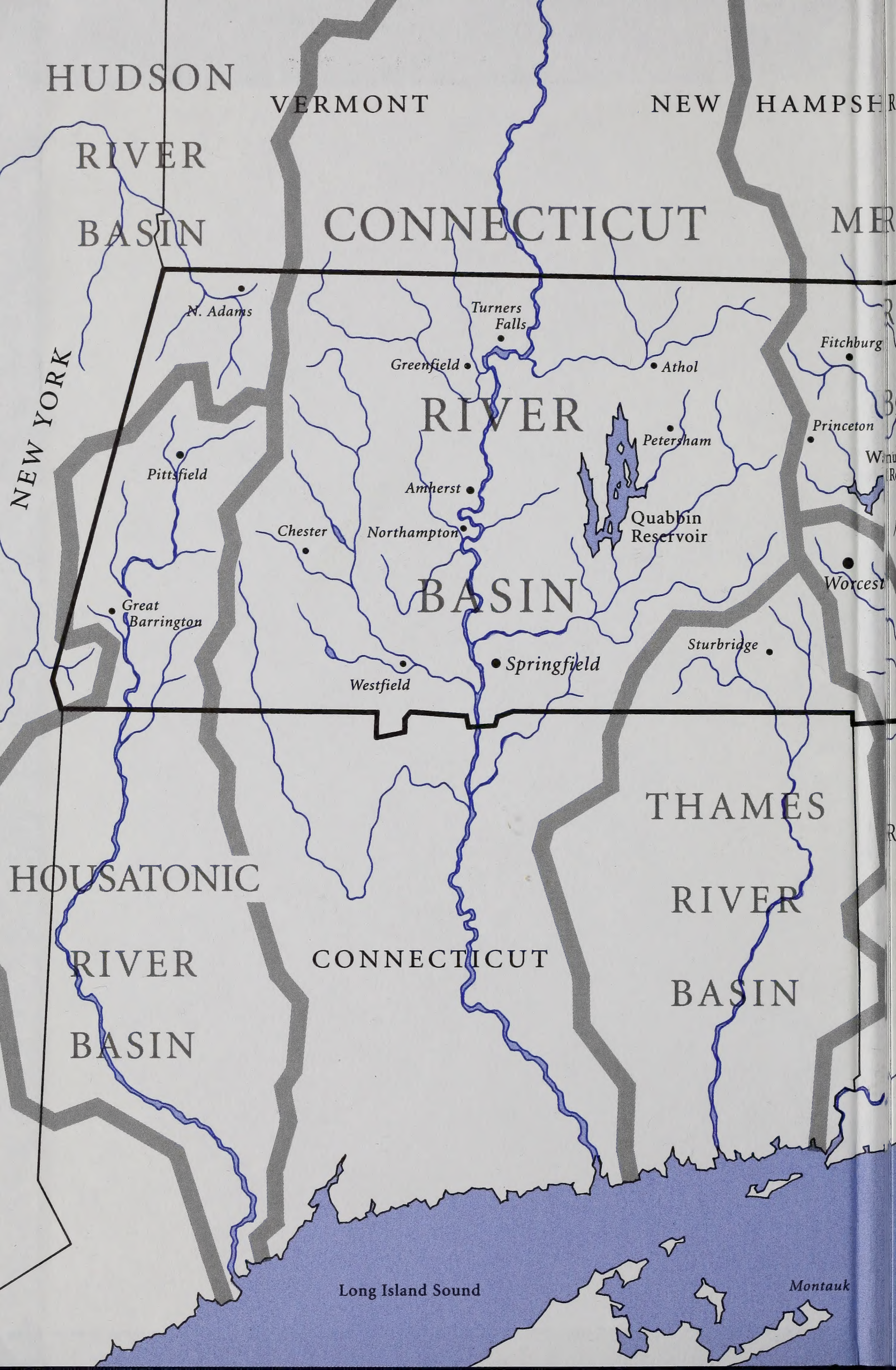
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Amherst
Quabbin Reservoir
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Sturbridge
Springfield
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Provincetown
Bridgewater
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Cape Cod
Bay
Middleboro
RHODE
ISLAND
Cape Cod
Canal
Orleans
Lakeville
Ponds
Barnstable
Chatham
Westport
SOUTHERN NEW ENGLAND
DRAINAGE AREA
Falmouth
Nantucket
Sound
MARTHA'S
VINEYARD
NANTUCKET

Inland Fishes of Massachusetts

Inland Fishes of Massachusetts

Karsten E. Hartel, David B. Halliwell, and Alan E. Launer

Illustrated by Laszlo Meszoly

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This book is written for those who care about and enjoy
Massachusetts wetlands and the resident aquatic animals and plants.

It is particularly dedicated to the following individuals
who have contributed to our understanding of local fishes,
aquatic ecology, and fisheries management.

THOMAS J. ANDREWS, BRITTON C. McCABE, PETER H. OATIS, ROGER J. REED

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Preface

Why a new book on Massachusetts fishes?

For some people, the answer to this question may be linked to the simple pleasure of observation. The ancient, yearly spectacle of the spawning migration of fishes into our coastal streams—though sadly dwindled—continues to inspire wonder for anyone who makes the effort to follow them on their aquatic journeys.

For other people, a fascination with fishes is linked to the recreational pursuit of species that offer sustenance as well as the opportunity to reconnect with the natural world, a need felt more acutely in our largely urban and technological culture. Still others recognize that protecting the diversity of life on this planet is essential to the health of ecosystems upon which all of us depend. Fishes are a vital part of the local ecosystem and food web because they eat smaller animals, plants, and fishes, and, in turn, they serve as food for many other creatures.

The diversity of native freshwater fishes in Massachusetts is modest due to natural limiting factors such as geology, climate, and water chemistry. To these natural pressures on our native fauna, we have added stresses directly related to intensive, widespread human settlement. These include the excessive use of surface water and groundwater, the clearing of much of the land's mature vegetation—predominantly temperate forests in Massachusetts—and the conversion of forested areas to intensive agricultural use beginning early in the colonial period. Subsequently, industrialization exploited the region's waterways for transportation, energy production, and the disposal of various, often toxic, wastes. Finally, we have introduced a variety of exotic fish species, either to improve sportfishing opportunities or through the careless release of live bait. As a result of all these human interventions, populations of some native inland species of fishes in Massachusetts have been reduced; and today introduced species comprise 45 percent of the state's primary freshwater ichthyofauna.

We live at a point in the earth's history when extinction of the planet's flora and fauna is proceeding at an unprecedented and alarming rate. Any efforts to slow and eventually stop this trend must be predicated upon knowledge of key facts: Which species occur in which habitats and watersheds? What aspects of their life histories are critical to their survival? Which species are threatened with obliteration and why?

The publication of *Inland Fishes of Massachusetts* gives us, for the first time, the answers to many crucial questions and makes a splendid contribution to our understanding of the Commonwealth's natural history. Here are refreshingly decipherable keys to identification—accompanied by precise line drawings and color photographs; comprehensive species accounts with sections on identification, natural history, distribution, and abundance; summaries of Massachusetts ichthyology, fisheries, ecology, conservation, and fish watching; and an extensive bibliography.

Inland Fishes of Massachusetts establishes the baseline against which all future studies of the freshwater fishes of this state will be measured. It is an indispensable addition to the library of all New England naturalists and sportfishers.

Gary R. Clayton
Vice President for Programs
Massachusetts Audubon Society

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Inland Fishes of Massachusetts

Introduction

This is the first detailed guide to Massachusetts freshwater fishes and their distribution. Its primary aim is to present updated information on the identification and distribution of these fishes to both the beginner and the professional. In addition, we have included brief outlines about the natural history and status of the fauna. This book is designed to meet the needs of anglers, aquatic resource managers, conservation groups, educators, naturalists, and the general public. We hope that the information presented here will make the reader more aware of aquatic resources and the natural heritage of Massachusetts.

Fishes have played an important role in Massachusetts' history. The Native Americans used them as food and fertilizer, and the first European explorers marveled at their abundance. The large number of fishes attracted numerous settlers to New England. Early colonists found the marine waters full of cod, herrings, and flatfishes and the estuaries and rivers rich in shad, sturgeons, and Striped Bass. Even the "lowly" Sea Lamprey supported a local fishery during this era.

When the colonists wrote of the abundance of fishes they were referring to the great quantities of a few, largely marine, species and not to the numbers of different kinds of fishes. Native freshwater fishes in Massachusetts are a naturally depauperate fauna. The low number of native species is due primarily to the glaciers that covered all of Massachusetts as recently as 14,000 years ago. The intervening years are a short time in a geological sense, and only a few species found their way into the deglaciated areas. For example, 50 or so native species are known from New England, whereas nearly 300 are known from the Appalachian region.

Far beyond their obvious value to humans as a source of food and recreation, fishes are vital components of aquatic ecosystems. Fishes both eat and are eaten in a food chain where algae and invertebrates are converted into food for fishes and other animals, including humans. About one-third of all bird species found in Massachusetts eat fishes at some time during

their lives. In fact, fishes are a life-sustaining necessity for some birds, including loons, grebes, cormorants, herons, mergansers, Bald Eagles, Ospreys, and terns. Fishes are also directly important to some mammals, reptiles, amphibians, and invertebrates: otters, mink, water shrews, turtles, snakes, diving beetles, and dragonfly larvae all eat fishes. In addition, the existence of most freshwater mussels would be impossible without fish because larval mussels spend the first part of their lives attached to the gills of living fishes.

The interwoven relationship of water, fishes, birds, other animals, and plants is complicated. It can be affected by atmospheric input from hundreds of miles away, downstream flow from other states, local construction, agricultural runoff, changes in groundwater, or the introduction of additional species into the web. The delicate aquatic ecosystem must always be considered when studying fishes because their world is so closely related to and yet so very different from our own.

Today, none of Massachusetts' freshwater fishes, except possibly eels and herrings, which are caught at sea, are harvested commercially. However, vast numbers of people enjoy the recreational value of fishing the state's waters. Between 1986 and 1995, approximately 270,000 fishing licenses were sold each year in Massachusetts. These fees generated 3.5 million dollars annually for the Massachusetts Division of Fisheries and Wildlife (Cardoza 1997, pers. comm.). A high percentage of these funds is directed to gamefish related activities that often indirectly benefit the full aquatic ecosystem. In addition, a national survey (Anon. 1993) estimates that some 652,000 anglers spent 454 million dollars while pursuing their sport in the marine and freshwater areas of Massachusetts in 1991.

Outline of This Book

This book focuses on Massachusetts freshwater fishes and does not cover the local marine species or fishes found outside of the state; nor does this guide deal in detailed accounts of fish anatomy, physiology, or behavior. However, small amounts of what we consider interesting related information are scattered throughout the book, and we have provided a general references section that indexes topics beyond the scope of this work.

It should be emphasized that this book and its identification keys are designed to be used with fishes found in Massachusetts freshwaters. Although

they apply generally to most New England freshwater fishes, they will not work with some species from the Lake Champlain and Saint Lawrence drainages of northern Vermont, New Hampshire, and Maine.

In addition to introductory material, this book is divided into three parts: illustrated keys for identification of families and species; an annotated synopsis of all families and species known from the state, with selected comments on their biology and conservation; and reference material. The reference material includes literature cited, general fish references (Appendix 1), a table summarizing the distribution of each species by drainage areas (Appendix 2), and a glossary (Appendix 3).

Fishes in General

Fishes may be best described as vertebrate animals that breathe through gills and have median fins with skeletal supports. However, many of the approximately 25,000 species found worldwide lack one or more of the common attributes often associated with fishes: many lack scales, others are blind, and some even breathe air. Fishes are truly remarkable in that they occur in a far wider variety of habitats than any other vertebrate group. They live in areas that range from high mountain lakes at 12,500 feet, to ocean canyons deeper than five miles. Certain species can survive the subfreezing Antarctic water by using a natural antifreeze in their blood, and others have adapted to African hot soda lakes at temperatures close to 120°F. Fishes break many general biological rules in various ways: some change their sex, die almost immediately after reproducing, catch food on land, produce an electric field for communication and prey capture, find their homestreams by smell or have all female species, and some fishes can even be said to "sing" or to "fly." In general, Massachusetts freshwater fishes are not quite so diverse in their habits, but each species is fascinating in its own right and has an interesting story to tell.

Massachusetts Fishes—Who's Related to Whom

Three major divisions of the vertebrates are most often called fishes: the jawless fishes (lampreys and hagfishes); the cartilaginous fishes (sharks, skates, and rays); and the bony, ray-finned fishes (minnows, trout, bass, and many others). The relationships and classification of most of the major

Table 1 A classification of the families of freshwater fishes found in Massachusetts (modified from Nelson 1994, Stiassny et al. 1996).

JAWLESS FISHES (formerly AGNATHA)							
	Cephalaspidomorphi					Petromyzontiformes	
							Petromyzontidae (lampreys)
GNATHOSTOMATA							
	Actinopterygii					Acipenseriformes	
							Acipenseridae (sturgeons)
						Amiiformes	
							Amiidae (bowfins)
		Teleostei					
			Elopomorpha				
						Anguilliformes	
							Anguillidae (freshwater eels)
			Otocephala				
				Clupeomorpha			
						Clupeiformes	
							Clupeidae (herrings)
							Engraulidae (anchovies)
				Ostariophysi			
						Cypriniformes	
							Cyprinidae (minnows)
							Catostomidae (suckers)
						Siluriformes	
							Ictaluridae (bullhead catfishes)
			Euteleostei				
				Protocanthopterygii			
						Salmoniformes	
							Salmonidae (salmon)
							Osmeridae (smelt)
				Neognathi			
						Esociformes	
							Esocidae (pikes and pickerels)
							Umbridae (mudminnows)
				Paracanthopterygii			
						Gadiformes	
							Gadidae (codfishes)
						Percopsiformes	
							Percopsidae (trout-perches)
				Acanthopterygii			
					Mugilomorpha		
						Mugiliformes	
							Mugilidae (mullets)
					Atherinomorpha		
						Atheriniformes	
							Atherinopsidae (silversides)
						Beloniformes	
							Belonidae (needlefishes)

Table 1 (*continued*).

	Cyprinodontiformes	
		Fundulidae (killifishes)
		Cyprinodontidae (pupfishes)
Percomorpha		
	Gasterosteiformes	
		Gasterosteidae (sticklebacks)
	Syngnathiformes	
		Syngnathidae (pipefishes)
	Scorpaeniformes	
		Cottidae (sculpins)
	Perciformes	
		Moronidae (striped basses)
		Centrarchidae (sunfishes)
		Percidae (perches)
		Carangidae (jacks)
	Pleuronectiformes	
		Achiridae (American soles)

groups of Massachusetts freshwater fishes are shown in Table 1. In variety, our local fishes range from the most "primitive" lampreys to the most "advanced" bony fishes, the teleosts.

Within these three divisions, Massachusetts fishes are further split into classes, orders (names ending in "iformes"), and families (names ending in "idae"). Orders contain closely related families, and families contain related genera and species. Thus, each species fits into a multi-tiered classification. Table 1 shows all of the families of fishes found in Massachusetts in a hierarchical format. Information from the study of anatomy, life history, and biochemistry allows scientists to link or separate groups of animals. Much has been learned over the last two decades about the interrelationships of fishes, but there are a few groups in which distantly related fishes are still lumped together into unnatural (paraphyletic or polyphyletic) groups. The study of relationships, called "systematics," places animals in a framework that allows comparisons between and among groups and, therefore, is crucial to the understanding of variations in fish behavior, physiology, ecology, and management.

The most basal of Massachusetts' fishes are the jawless lampreys, which have survived hundreds of millions of years with little change. Although

seemingly primitive, they are well adapted to their habitat and behavior. The lampreys were at one time placed in the class Agnatha, but that assemblage has recently been called into question as lampreys are probably more closely related to jawed fishes than to the jawless hagfishes. All other vertebrates, from sharks to mammals, belong to the jawed Gnathostomata.

The jawed fishes are divided into the cartilaginous sharks, skates, and rays, and the bony fishes. The sharklike forms have individual gill slits and lack a bony skeleton. While none of these fishes occur in Massachusetts freshwaters, some sharks have been found as far up the Mississippi River as Illinois. The bony fish group contains the ray-finned fishes (Actinopterygii) and the lobe-limbed vertebrates (Sarcopterygii). Many extinct fishes, along with the living lungfish (Dipnoi), and all amphibians, reptiles, birds, and mammals belong to the lobe-limbed group.

Sturgeons and the Bowfin are Massachusetts' representatives of two ancient groups of primitive ray-finned fishes that date back 300 million years and have few surviving members. All other Massachusetts ray-finned fishes are members of the more advanced Teleostei, a diverse group with some 20,000 species found in virtually every aquatic habitat around the world. Teleosts have posterior vertebrae that expand into plates that give support to a symmetrical tail or caudal fin.

Massachusetts teleosts can be arranged into six subgroups: the eels (Elopomorpha); the herrings (Clupeomorpha); the minnows and relatives (Ostariophysi); the salmonlike fishes (Protocanthopterygii); the pike, pickerels, and relatives (Neognathi); the codlike fishes placed in the paraphyletic Paracanthopterygii; and the more advanced teleosts (Acanthopterygii). The fishes in the eel group are combined because they have a specialized, wafer-thin larva, the leptocephalus. The herringlike fishes, which include herrings and anchovies, all have a stethoscopelike connection between the swim bladder and the ear. The minnows, suckers, and catfishes are placed in the Ostariophysi because of the development of the anterior vertebra into a specialized organ called the "Weberian apparatus."

The last major teleost subgroup, the Acanthopterygii, is united based on the position of a muscle associated with the upper set of pharyngeal jaws. Acanthopterygian fishes of Massachusetts include the mullets (Mugilomorpha), the silversides, killifishes, pupfishes, and needlefishes (Atherinomorpha), and the advanced spiny-rayed fishes (Percomorpha). The spiny-rayed fishes encompass the widest array of fish families: the stickle-

backs, the sculpins, the perchlike fishes, and the specialized flatfishes (Pleuronectiformes).

REFERENCES. Lauder and Liem 1983; Moser et al. 1984; Johnson 1992; Burr and Mayden 1992; Stiassny et al. 1996 (relationships); Nelson 1994; Eschmeyer, ed. 1998 (systematic list of all fish groups); Wiley 1981; Mayden and Wiley 1992 (systematic practice and theory).

Ichthyology in Massachusetts

"There are in the rivers, and ponds, very excellent Trouts, Carpes, Breames, Pikes, Roches, Perches, Tenches, Eeles, and other fishes, such as England doth afford, and as good, for variety; yea many of them much better..." Thomas Morton writing of the Massachusetts Bay area in the 1630s (Morton 1972).

The Study of Fishes

Although Massachusetts had been explored by Europeans as early as 1602, little ichthyological information was published until the early 1800s. The first in-depth freshwater fish survey of Massachusetts, including only the western portion of the state, was not undertaken until 1940. It is unfortunate that surveys were not made in the earlier years because many questions will never be answered about the former distribution and abundance of Massachusetts fishes.

Prehistoric Records The first records of postglacial Massachusetts fishes come from sparse remains of fishes found at Native American archaeological sites that date from 5,000 years ago to the early 1600s. The comparatively small amount of New England archaeological material is probably due to the methods of food processing or its transportation from site to site and the poor quality of the preservation of fish bones in New England's climate and acidic soils. A recent review of fish remains at archaeological sites in New England (Carlson 1988) lists 27 marine species, 6 anadromous species, and 4 groups of freshwater fishes (minnows, catfishes, sunfishes, and perches). In addition, Huntington (1982) found remains of Brook Trout at a site in Marlborough, and Fallfish and Chain Pickerel have been recently identified from an important shell heap along the Sudbury River (Smith 1940, Largy 1995).

Nearly all local fishes might have been used by the Native Americans, but it seems odd that more remains of freshwater fishes have not been discov-

ered at inland archaeological sites. Remains of anadromous species have frequently been encountered at both inland and estuarine sites in Massachusetts; bones from Atlantic Tomcod, river herrings, and American Eels have been found at a site in Marlborough (Huntington 1982), American Shad and river herrings at Turners Falls, and sturgeons along the Merrimack River. William Wood (Vaughan 1977) reports that the first Europeans saw the Native Americans fishing for sturgeon with strong nets during the day and with torches and spears at night.

Atlantic Salmon have been logically considered a seasonal mainstay in New England by many historians but, surprisingly, Atlantic Salmon remains have not been found at any Massachusetts archaeological sites and have been positively reported at only one site in Maine. A recent study by Carlson (1988:65) states "archaeological faunal evidence for fishing in New England does not suggest a heavy utilization of Atlantic Salmon [*Salmo salar*] in either coastal, estuarine, or riverine settings..." and "...all available evidence indicates that salmon was an extremely minor component of the prehistoric resource base," but the results of this study may be biased by centuries of New England climate.

The Early Years (1600 to 1830) The first records of the fishes of New England come from the journals and notes of the early adventurers. Most of these reports mention only species of economic importance or of curious nature; almost all fail to mention freshwater fishes. The earliest accounts, from Bartholomew Gosnold's 1602 voyage to Cape Cod and Buzzards Bay, mention eight species of marine fishes and comment on their quality and abundance (Archer 1843, Brereton 1906). John Smith's accounts briefly mention sturgeons, perches, and eels (Smith 1986). The first actual list of species by John Josselyn in 1672 contains about 46 species and concentrates primarily on marine food fishes, but it also includes species from as far south as Virginia (Lindholdt 1988).

Although the early reports offer an incomplete picture of the fishes of Massachusetts, one feature is fairly well documented—fishes were once far more abundant than they are today. Almost all early accounts mention great quantities of herrings, sturgeons, Striped Bass, and Atlantic Salmon. Some of the accounts seem believable, while others contain more fanciful descriptions. Wood writes in 1634 (Vaughan 1977) that "sturgeons be all over the country, but the best catching of them is upon the shoals of Cape Cod and in the river of Merrimack, where much is taken, pickled and

brought to England. Some of these be twelve, fourteen, eighteen foot long." Alewives are "in such multitudes as is almost incredible, pressing up in such shallow waters as will scarce permit them to swim, having likewise such longing desire after the fresh water ponds that no beatings with poles or forcive agitations by other devices will cause them to return to the sea till they have cast their spawn." Wood further states that "below this fall of waters [Charles River at Watertown] they [the inhabitants of the town] take great stores of shads and alewives. In two tides they have gotten one hundred thousand...." Striped Bass were likewise described: "some be three and some be four foot long, some bigger, some lesser. At some tides a man [with hook and line] may catch a dozen or twenty in three hours." In the spring, Striped Bass were taken in rivers with nets, "sometimes two or three thousand at a set."

In 1804, the first American scientific paper on New England fishes was written by William Dandridge Peck (1763–1822). This work, entitled *Description of Four Remarkable Fishes taken near the Piscataqua in New Hampshire,* did not describe freshwater species. However, Peck, who was appointed natural history professor at Harvard in 1805, did collect some freshwater fishes. The Harvard Museum of Comparative Zoology houses 11 dried skins of New England freshwater fishes, collected by Peck between 1790 and 1793, which have handwritten labels showing that many are from the Piscataqua River; however, one Rainbow Smelt is labeled from Boston. The other species include the Sea Lamprey, Alewife, White Perch, Pumpkinseed, and Yellow Perch. These dried preparations represent some of the oldest natural history material available from the United States.

In 1816, Charles A. Lesueur (1778–1846), a French ichthyologist, visited Boston shortly after arriving in the United States and described a number of local species based on the material that he found. All these species, however, had been described by earlier ichthyologists, especially by Samuel Latham Mitchill in his accounts of New York fishes. Mitchill and two other New Yorkers, Alexander Wilson and DeWitt Clinton, preceded Lesueur and all the early Massachusetts ichthyologists in first describing many of the East Coast species from their studies between 1814 and 1824.

The Middle Years (1830 to 1900) The first lists of Massachusetts fishes were produced by a physician and one-term mayor of Boston, Jerome Van Crowningshield Smith (1800–1879; see Figure 1a) and included in Edward Hitchcock's 1833 and 1835 reports on the geology of Massachusetts. The

Figure 1a. J.V.C. Smith (1800–1879) compiled the first list of Massachusetts fishes. Courtesy Boston Public Library.

1b. D.H. Storer (1804–1891) prepared two major works and many papers on Massachusetts fishes. Courtesy Boston Museum of Science.

1835 report lists about 25 species of freshwater fishes that we can recognize based on the names that he used. In 1833, Smith had also produced a book called *Natural History of the Fishes of Massachusetts, Embracing a Practical Essay on Angling,* which was released again in 1843 with almost no revisions. Smith's work was severely criticized by his contemporary, D.H. Storer, and later by Theodore Gill in his history of the state's ichthyology (1904). Both Storer and Gill disapproved of Smith's fanciful accounts, his outdated taxonomy, his inclusion of European fishes, the use of European names for many local fishes, and his unabashed publication of illustrations from uncredited sources.

David Humphries Storer (1804–1891) (Garman 1891, Gifford 1964; see Figure 1b) was perhaps the most important figure in Massachusetts ichthyology. Storer was a Boston physician who published a number of medical papers as well as more than 60 articles on ichthyology, herpetology, and conchology over 30 years. His first papers were presented at meetings of the Boston Society of Natural History (now the Boston Museum of Science), which he helped to found. Among his earliest papers were the critiques of

Jerome Van Crowningshield Smith's lists (1836) and his first history of Massachusetts fishes.

In 1837, Storer was commissioned to produce a report to the state commissioners on the ichthyology and herpetology of Massachusetts. This endeavor, financed by the Massachusetts legislature, was produced in 1839. Storer expanded this work in a series of six papers called *A History of the Fishes of Massachusetts,* published in the Memoirs of the American Academy of Arts and Science between 1853 and 1867. The full series, published as one volume in 1867, contains almost 300 pages, 39 lithographed plates, and an appendix by Frederick Ward Putnam, an anthropologist and natural historian, that listed additional species. Storer's *History* is equivalent to the best of the state books of the period and was beautifully illustrated by Auguste Sonrel (Blum 1993). Like Lesueur, Storer named a number of species that had already been described by earlier authors. Only two of his New England freshwater species are considered taxonomically valid today: the Tessellated Darter, described from the Connecticut River near Hartford, and the Northern Pipefish, described from Nahant.

In 1859, Louis Agassiz (Lurie 1988, Winsor 1991) founded the Museum of Comparative Zoology at Harvard University and made major expeditions to Lake Superior and later to South America. His assistant Samuel Garman (1846–1927) (see Summers and Koob 1997) published a few papers on local fishes; but, in retrospect, it seems that the study of Massachusetts freshwater fishes held no deep interest for Agassiz and his colleagues. Presumably, they concluded that Storer had covered Massachusetts fishes in sufficient detail. Fortunately, a number of interesting freshwater specimens from this period were deposited in Agassiz's museum, among them some of the only records of the Longnose Dace and Slimy Sculpin from the Merrimack River in Massachusetts.

From the mid-1800s to the early 1900s, only a few additional papers on Massachusetts fishes appeared. In 1858, Charles Girard described the Swamp Darter and the Banded Sunfish from specimens collected in Massachusetts. In 1879, G. Brown Goode and Tarleton H. Bean of the United States Fish Commission published *A List of the Fishes of Essex County, including those of Massachusetts Bay.* This work deals primarily with the state's marine fauna, but also lists the freshwater species of Essex County. More importantly, Goode and Bean's report updated and corrected much of the confusion regarding the scientific and common names of local fishes.

The Quiet Years (1900 to 1940) In 1908, William Converse Kendall produced a *List of the Pisces* in the *Fauna of New England* series published by the Boston Society of Natural History. Kendall's work, mainly a literature survey, also cites many Massachusetts specimens from the collections of the Boston Society of Natural History. Over the years, most of the Boston Society's fish specimens, including some cited by Kendall, have been transferred to the Museum of Comparative Zoology. Kendall produced two monographs on the salmonid fishes of New England (char 1914, salmon 1935) that cover taxonomy, natural history, and historical status. He also published papers on silversides (1902), catfishes (1910), and smelt (1926).

During this period, Carl L. Hubbs (1894–1979), one of the most distinguished ichthyologists of the 20th century, spent a year at the Museum of Comparative Zoology reviewing North American freshwater fishes. Hubbs and his wife, Laura, made a number of fish collections around Massachusetts that shed interesting light on the relative abundance of the fishes during the late 1920s. The Hubbs' specimens are now housed at the University of Michigan in Ann Arbor.

In 1925, Dr. Henry Bryant Bigelow, a Harvard professor and founder of the Woods Hole Oceanographic Institution, and his colleague, W.W. Welsh, turned their attention to marine fishes and produced the first edition of *Fishes of the Gulf of Maine.* This monumental faunal work contains accounts of many of the diadromous and estuarine fishes that are sometimes found in Massachusetts freshwaters. *Fishes of the Gulf of Maine* was rewritten in 1953 by the team of Dr. Bigelow and William C. Schroeder, who together wrote numerous papers on sharks and rays.

The Recent Years (1940 to the present) The summer of 1940 marked a major turning point in knowledge of Massachusetts freshwater fishes. During that field season, Prof. Britton C. McCabe (1901–1968) (see Figure 2a) of Springfield College made 400 collections of fishes from sites in western Massachusetts (Map 1). McCabe's fieldwork formed the basis of his doctoral thesis from Cornell University on the fishes of the streams of western Massachusetts (McCabe 1942, 1943); this study was the first comprehensive fish survey in Massachusetts. McCabe became chairman of the Biology Department at Springfield College (1946–1963) and, during the summers between 1944 and 1952, was an aquatic biologist for the Massachusetts Division of Fisheries and Wildlife. Prof. McCabe initiated a series of lake and pond sur-

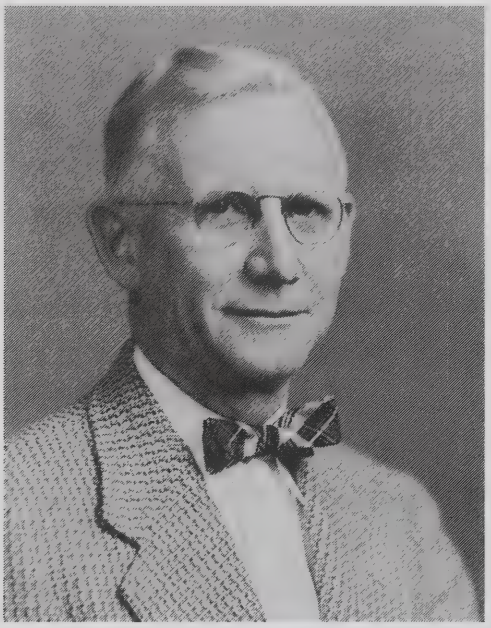


Figure 2a. B.C. McCabe (1901–1968) conducted the first in-depth survey of the state's freshwaters. Courtesy Mrs. B.C. McCabe.

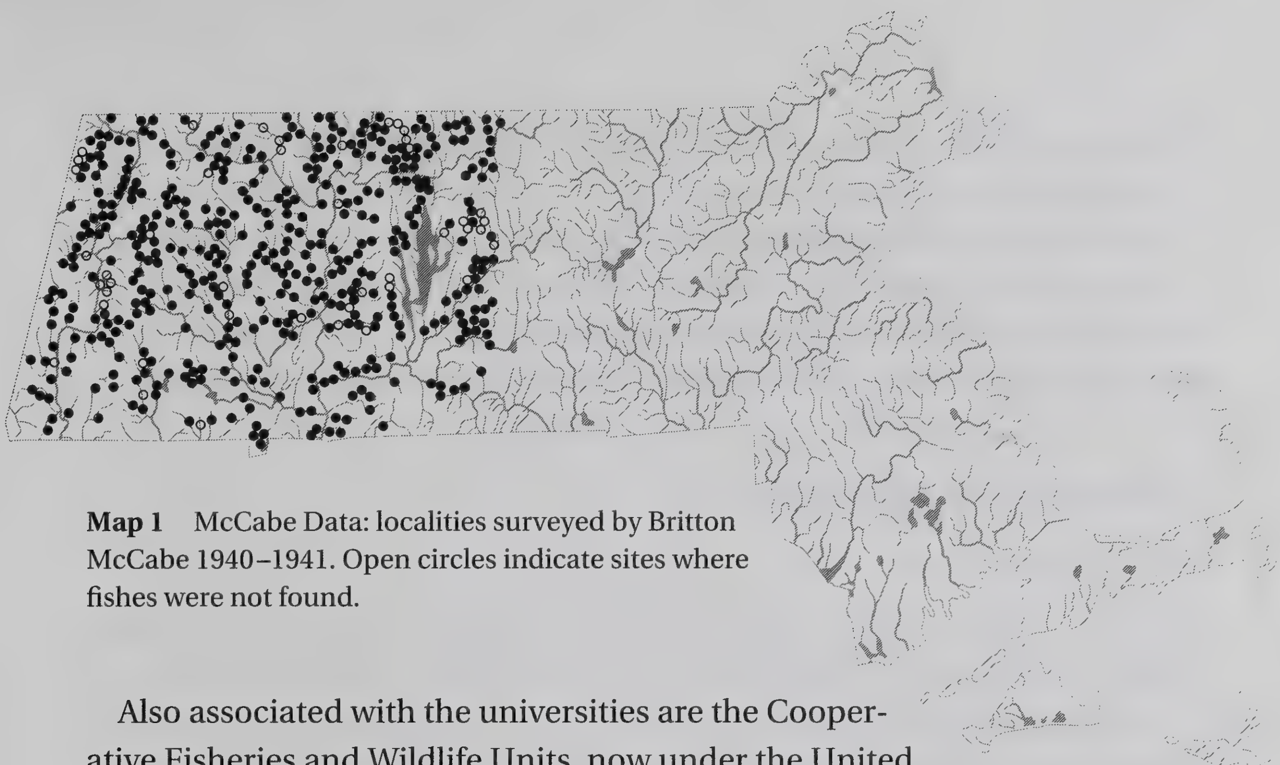
2b. R.J. Reed (1929–1979) conducted research and taught at the University of Massachusetts. Courtesy Mrs. R.J. Reed.

veys, from which he and his colleagues compiled six reports (McCabe 1948, 1952, 1953; McCabe and Swartz 1952; Stroud 1955; Swartz 1944).

Other colleges and universities began adding information in the mid-1900s. Prof. Thomas J. Andrews (University of Massachusetts, Amherst) made numerous collections all across Massachusetts, either by himself or with students, between 1948 and 1980. Andrews was the first to identify the Shortnose Sturgeon (Vladykov and Greeley 1963) and Bluntnose Minnow in Massachusetts. He avidly collected darters and studied their distribution and was the first to recognize the Swamp Darter on Martha's Vineyard.

From 1958 to 1963, Dr. Robert H. Gibbs (1929–1988) taught at Boston University. With students, he made a number of collections, especially in eastern Massachusetts. Gibbs' Boston University fish collections, transferred to the Museum of Comparative Zoology in 1978, contain records of some species, particularly the Bridle Shiner, from sites in eastern Massachusetts where they no longer occur.

In 1969, Paul S. Mugford (MDFW) produced the first modern guide to Massachusetts freshwater fishes, the *Illustrated Manual of Massachusetts Freshwater Fish.* This small book served the angling community for almost 25 years, but now its information is out-of-date.



Map 1 McCabe Data: localities surveyed by Britton McCabe 1940–1941. Open circles indicate sites where fishes were not found.

Also associated with the universities are the Cooperative Fisheries and Wildlife Units, now under the United States Geological Survey. The Massachusetts Cooperative Fisheries Unit at the University of Massachusetts, Amherst, is a federal research station cooperating with the university and the state. Much of the work at Amherst has revolved around the study of the anadromous fishes of the Connecticut and Parker rivers. Dr. Roger J. Reed (1929–1979) (see Figure 2b), Cooperative Unit Leader at Amherst and one of the driving forces behind restoration of the state's anadromous fishes, was much broader in his research. Reed and his students actively studied a broad spectrum, including parasites, aquatic invertebrates, and nongamefish species. Almost half of Reed's publications are on such topics, including life histories of the Fallfish (1971), Blacknose Dace (Reed and Moulton 1973), and Tessellated Darter (Layzer and Reed 1978) in Massachusetts and the Longnose Dace in Pennsylvania (1959).

Over the last two decades, ichthyological research has continued. David Halliwell produced the updated *A List of the Freshwater Fishes of Massachusetts* (1979 et seq.) and a Ph.D. thesis on Massachusetts streams and fish distribution (1989). During this time, Karsten Hartel at Harvard and Douglas G. Smith at the University of Massachusetts, Amherst, began a concerted effort to collect fishes all across the state. Hartel and Halliwell shortly joined forces with the long-term goal to produce this book. Lists of exotic or introduced Massachusetts fishes were produced by Hartel (1992) and Cardoza et al. (1993).

Anadromous fish work has expanded at the new S.O. Conte Anadromous Fish Research Lab at Turners Falls, which went into operation under the US Fish and Wildlife Service in 1990. Drs. Boyd Kynard, Henry Booke (now

retired), and Steve Rideout continue to study many species at that site. Active programs in ichthyology or fisheries biology exist at Southeastern Massachusetts University, the University of Massachusetts (Amherst and Boston), Boston University, and Harvard University. The New England Aquarium, Boston, through its research department, has also been instrumental in producing critical studies of the state's aquatic fauna and flora.

Fisheries, Past and Present

Fisheries Management For centuries, people have increased the yield of harvestable fishes by capturing, holding, spawning, rearing, and otherwise manipulating them, by modifying their environment, and by protecting them from overharvesting. Massachusetts was the earliest state to produce formal fisheries laws and regulations. Colonial acts were established as early as 1709 to control the erection of weirs or other obstacles that prevented the passage of fishes. Seine, hook and line, and night fishing in specific bodies of water were regulated by the turn of the 19th century. By the mid-1800s, Massachusetts had appointed commissioners to examine the status of fisheries (1855), artificial propagation of fishes (1856), and dams and barriers (1865). In 1869, the state set up a permanent Commission on Inland Fisheries, with each of its three members serving five-year terms.

During these early years, the state attempted the first official fish stockings. Rainbow Smelt were collected and transplanted to Boston's Jamaica Pond during the 1760s (Storer 1840). Black basses were introduced by 1850, American Shad fry were released into the Concord River in 1868, and the first Massachusetts hatchery at Agawam produced almost 40,000 salmon, trout, whitefishes, and chars between 1868 and 1870.

As declines in anadromous fishes and sea fisheries were noted (Lyman 1871), stocking continued at a fast pace to try to supplement or reestablish the native salmonid fishery. Hatcheries were established in the towns of Winchester (1870), Sutton (1902), Sharon, Norfolk, and Wilbraham (1912), and Sandwich (1914).

Commercial fishing of inland waters stopped long before the turn of the century, and as recreational fisheries developed, the state instituted its first fishing licenses. In 1919, anyone fishing stocked waters was required to have a license, and, by 1930, a license was required to fish all inland waters.

The Massachusetts Division of Fisheries and Wildlife (MDFW) is the agency that directly oversees the freshwater fisheries of Massachusetts. Its

history can be traced back to the commissioners of the 1850s. Through the years, its primary concerns have often been with enhancement of recreational fisheries, but, since the late 1970s, this agency has gradually become more involved with the overall aquatic ecosystem. However, over the past several decades, research and protection of both game and nongame fishes are becoming balanced. The division's Endangered Species and Natural Heritage Program, the primary state agency responsible for rarer fishes, is almost completely supported by donations from the citizens of Massachusetts through an income tax write-off system.

Success at the Fishways One of the most dramatic and noticeable declines of New England fishes before the loss of marine ground fisheries late in the 20th century (Fogarty and Murawski 1998) was caused by dam construction, which eliminated thousands of miles of stream habitat for anadromous fishes. As settlements were established, canals and then dams were built to aid commerce and manufacturing. By 1798, a dam was in place in Massachusetts at Turners Falls in Montague on the Connecticut River. This dam was followed by structures at Holyoke on the Connecticut (1849) and Lawrence and Lowell (1847) on the Merrimack. These dams limited migratory runs to less than 90 miles on the Connecticut and about 30 miles on the Merrimack, thus eliminating vast areas of the river basins for reproduction and juvenile growth of such important migratory species as sturgeon, Atlantic Salmon, American Shad, Alewife, and Blueback Herring.

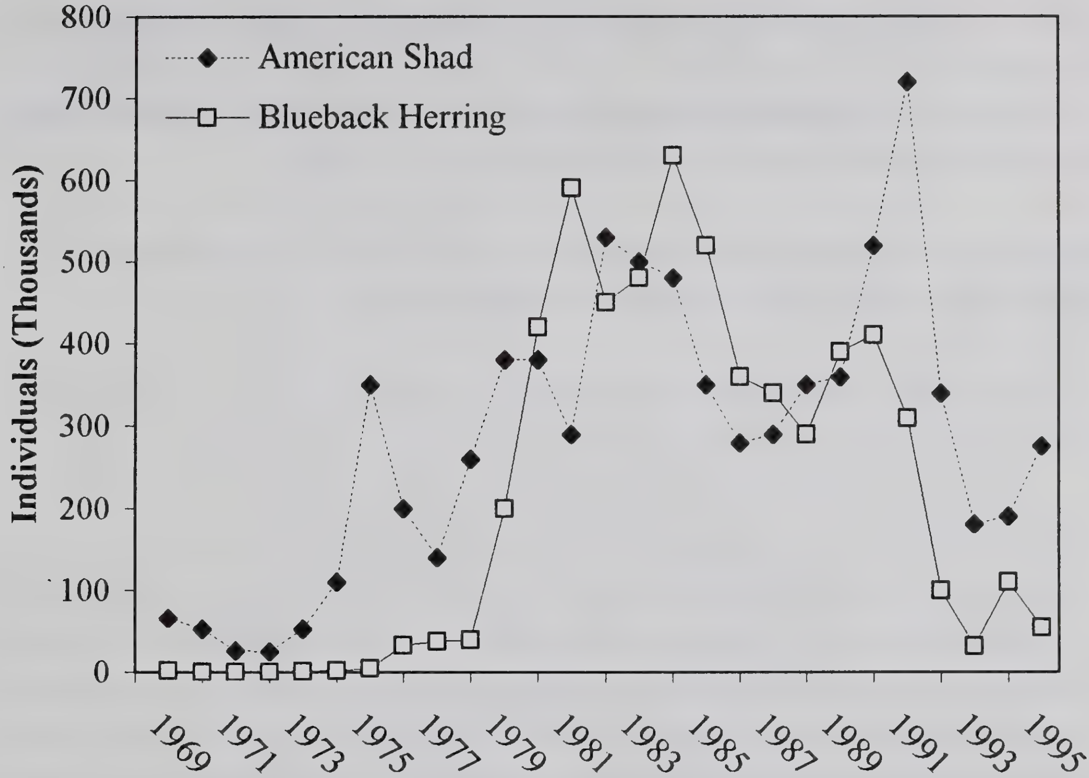
By 1865, state-appointed commissions were examining the problem, and the Supreme Court ruled that the owners of the dams were responsible for installing and maintaining fishways. The first fishways were put in place by the early 1890s, but the long series of attempts to construct or improve fish passage, which lasted until almost 1950, was largely ineffective. Stocking was also attempted during these years but was negated by the fact that returning adult fishes could not swim upriver. By 1949, court orders and new technology came into play when the Holyoke Power Company was mandated to build fish passage facilities around their new power station at Holyoke. The first designs met with little success until 1955, when federal fisheries personnel and the power company built the first successful upstream passage facility in the Northeast (Moffitt et al. 1982). This elevator system is a large box or hopper into which fishes are attracted by current, captured, lifted to the height of the dam, and released into the upper impoundment. The operation of this facility opened 36 miles of river be-

tween Holyoke and Turners Falls to diadromous fishes for the first time in 100 years.

All of the major fishways in Massachusetts, at Westfield, Holyoke, Turners Falls, Lowell, and Lawrence, are now operational. In addition, the establishment of the S.O. Conti Anadromous Fish Laboratory at Turners Falls, which has a large flume area to test designs of new fishways, will help to improve the designs. Operation of the fishways, stocking programs, and related research are expensive and would not have been possible, and will not continue, without town, state, and federal agencies cooperating with conservation agencies and the large power companies.

The fishways have worked for many of the anadromous species. For example, on the Connecticut River over 8 million American Shad and almost 6 million Blueback Herring have been passed through the Holyoke system since 1955. Other species that were somewhat unexpected, such as Striped Bass (8,400 since 1979) and Gizzard Shad (6,700 since 1986), have been lifted in good numbers. The real "king" of the river, the Atlantic Salmon, has been slower to reestablish itself, with only 3,000 handled at Holyoke since 1977. The numbers of fishes handled at Holyoke between 1969 and 1996 are shown in Figure 3. Note the general increase in American Shad and Blueback Herring through the early 1980s and the lower numbers in the mid-1990s. The cause of the decline is poorly understood and may be related to a combination of many factors. Some fisheries biologists think it might be related to the expanding population of Striped Bass that occurred after the mid-1980s (O'Leary 1998, pers. comm.). Of course, once the fishes have spawned and the juveniles are free-swimming, they must get back downstream. A number of obstacles that are inherently related to dam operation can kill fishes, including the turbines themselves. Downstream passage facilities are already in place at many dams, and their design has been the focus of discussion between regulators and dam owners, especially over the past five years (M. Tisa 1998, pers. comm.).

Concurrent with the recent fishway development, there has been an interagency effort to restore Atlantic Salmon to the Connecticut and Merrimack rivers. Two-year-old juvenile Atlantic Salmon from Canada were released in the Connecticut River and the first adult returned in 1974. Penobscot River juveniles were released into the river in 1976, and 90 adults returned in 1978. As shown in Figure 3, salmon have usually returned in the hundreds each year. By the late 1980s, supplemental stocking of salmon fry



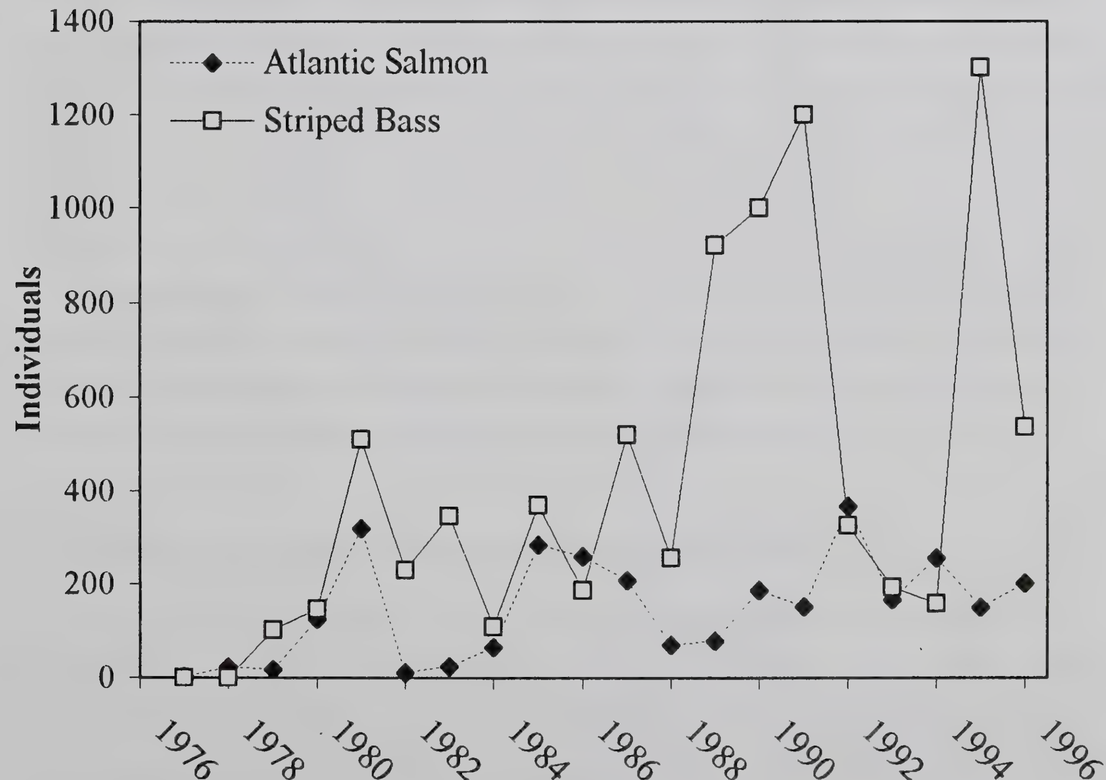


Figure 3. Fishes passed at the Holyoke Fish Lift, Connecticut River.

added to the recovery effort, and, by the spring of 1997, the total number of fry stocked in the Connecticut Basin was nearly 8.5 million. As mentioned in the Atlantic Salmon account, a few instances of natural reproduction in the wild have been reported (O'Leary 1997, pers. comm.).

REFERENCES. Moffitt et al. 1982, Anon. 1997a, 1997b (Connecticut River restoration); Meyer 1999 (recoveries and declines).

Conserving and Enjoying Fishes and the Aquatic Environment

Freshwater fishes are declining worldwide due principally to degraded or changing habitats. The exact reasons for the declines are often difficult to attribute to any one cause and usually are tied to multiple factors. The aquatic ecosystems of New England have been altered for almost four centuries; indeed, every body of water in Massachusetts has been negatively impacted in one way or another. The physical, chemical, and biological characteristics of Massachusetts freshwaters have been changed since the colonial days by settlement and subsequent agricultural or industrial expansion. Zaitzevsky (1982) notes that, as early as 1645, every marsh within the town boundaries of Boston had been modified in some way. Since colonial times, small- and medium-sized dams, used for grain and sawmills, changed the characteristics of the local environment. Virtually all of Massachusetts was cutover for timber, and 65 percent of the state was fully cleared for agriculture by the mid-1800s. The effects of this massive deforestation on the aquatic community due to increased runoff, siltation, and increased water temperatures will never be known and can only be presumed. However, damming and industrial or urban waste disposal from development have had a well-documented effect on local fishes. This is particularly true in regard to the large food fishes, such as the Atlantic Salmon, American Shad, and sturgeons that return seasonally to the rivers.

Conservation of North American Freshwater Fishes

In North America, 3 genera, 27 species, and 13 subspecies of freshwater fishes have become extinct over the last century (Williams and Miller 1990). At least 300 species, subspecies, or populations are currently listed at some level of rarity in North America. Thus, approximately one-third of the North American freshwater fish fauna is impacted. Imperilment is not restricted to any particular taxonomic group but is higher in areas of greater endemicity

(Warren and Burr 1994). Even many recognized but not yet scientifically described fishes are declining as documented by Williams et al. (1989).

Massachusetts has only two species on the North American rare fish list developed by Williams et al. (1989): the Atlantic and Shortnose sturgeons. Both of these species are listed under the Federal Endangered Species Act. Seven other species are listed in state categories: the Lake Chub and Northern Redbelly Dace are State Endangered; the American Brook Lamprey and a trimorphic freshwater population of Threespine Sticklebacks are State Threatened; and the Eastern Silvery Minnow, Longnose Sucker, Bridle Shiner, and Burbot are listed as State Special Concern. In addition, a number of other species, such as the Common Shiner, have been studied as possible list candidates by various private and state agencies.

It is easier to understand why it is important to conserve the native freshwater fishes of Massachusetts if they are viewed on a national or worldwide basis. Most of Massachusetts native fishes belong to a group of fishes found along the Atlantic coastal plain from Florida to southern Maine, and many of these species are found no place else in the world. The Atlantic coastal plain is quite small when viewed globally and also quite endangered; on top of it sits the giant East Coast megalopolis. This megacity that once sprawled from Boston to Washington, DC, now essentially engulfs the whole span from Miami to Portland, Maine, with only remnant natural areas scattered along the way.

Ecological Considerations and Local Fish Distribution

Fishes are totally integrated with their aquatic world and highly dependant on the quality and size of their environment. The distribution of most inland fishes is limited by each species' physiological constraints or behavioral requirements. Some species, such as Slimy Sculpin, Longnose Sucker, and salmonids, require relatively cold and clean water. Others, such as White Sucker and Brown Bullhead, tend to be more tolerant of a wider range of aquatic conditions to live healthy lives.

Streams and rivers vary naturally according to flow, volume, gradient, substrate, temperature, and water chemistry. Within these various conditions, fishes tend to be distributed in fairly predictable patterns. For example, in small, cold Massachusetts headwater streams, Slimy Sculpin and native Brook Trout may be the only species found. Farther downstream, Blacknose and Longnose dace as well as White Suckers may also be present. Still

farther downstream, in larger and slightly warmer midreach sections of streams, Common Shiners, Fallfish, and Tessellated Darters tend to become more prevalent, while trout and Slimy Sculpin become scarce. In lowland stream environments, warmwater species, such as the Pumpkinseed, Redbreast Sunfish, Brown Bullhead, Golden Shiner, Redfin Pickerel, Chain Pickerel, American Eel, Banded Sunfish, and Swamp Darter, become more dominant.

Lakes and ponds throughout the state, as well as impounded sections of rivers, also tend to be inhabited by an assemblage of warmwater fish species, including Brown Bullhead, Pumpkinseed, Bluegill, Largemouth Bass, Redbreast Sunfish, Golden Shiner, Yellow Perch, and Chain Pickerel. Very few of the state's lakes and ponds naturally support large numbers of coldwater fishes, except the large reservoirs such as Quabbin and Wachusett, where introduced Lake Trout and Atlantic Salmon are found.

The precise combination of species present at any given location depends on many factors, but, within any drainage, the number or diversity of native fishes from small upland headwaters to larger lowland rivers increases naturally. However, human activities, including the introduction of non-native fish species, pollution, and dams, have had significant impacts on native fishes, and, in many drainages, natural patterns of distribution and abundance no longer exist. Unfortunately, these human-caused disturbances are ubiquitous, and even those activities that traditionally have been considered "low-intensity" are now known to cause problems.

A study of a warmwater stream in Virginia (Weaver and Garman 1994), for example, has shown that gradual urbanization led to declines in abundance of all species and trophic groups, and six species were lost during the 38-year study period even though no exotic fishes were introduced. These low-intensity factors, such as gradual human population increase, new homes, new roads, and road crossings at streams, are very likely major causes of degraded aquatic ecosystems around all metropolitan areas in Massachusetts.

Other studies of randomly selected northeastern lakes by the U.S. Environmental Protection Agency (Whittier et al. 1997) showed a regional decline in minnow species. This decline was attributed to human development of lake shorelines and the presence of non-native predatory fishes.

The effects of acid precipitation are also a major problem for many of Massachusetts' aquatic ecosystems (Halliwell 1985). Above and beyond just simply lowering pH, which in itself can cause declines in the survival

of larvae and eggs and the availability of prey, increased acidification can alter water chemistry in numerous ways, including allowing various potentially toxic metals to more easily enter local ecosystems. A study in eastern Massachusetts comparing two ponds, one with low acid-buffering capacity and another with higher buffering capacity (Stallsmith et al. 1996), shows vulnerability to acid spikes early in a fish's life, as the first gills begin to develop, along with poor growth rates.

REFERENCES. Deacon et al. 1979, Williams et al. 1989 (declining North American fishes); Miller et al. 1989 (extinct North American fishes); Williams and Miller 1990 (conservation status); Foster 1992, 1999 (land use, MA); Haines and Baker 1986 (acidification).

Fishwatching and Fish Photography

Humans have always been fascinated with the behavior of fishes and have woven them into mythology and folklore. When one thinks of watching fishes, the first thing that comes to mind is the coral reef environment; however, ponds and streams in Massachusetts offer good opportunities to observe and photograph a number of interesting species.

Observing Fishes Fishwatching is by no means a new idea, but today's cameras, underwater housings, strobe lights, wet suits, face masks, snorkels, scuba, and miniature tape recorders have opened worlds below water that were impossible to access 50 years ago. Even with today's equipment, fishwatching starts with patience and the ability to sit quietly. Many fishes are easy to see; nesting sunfishes can be watched by standing on the shore at almost any pond during early summer. Anadromous fishes, such as the Alewife, can be seen in incredible numbers as they pass up fishways on both small and large streams. The general public is allowed to view the major fishways on the Connecticut and Merrimack rivers. Other fishes are more difficult to see, and the watcher may have to sit still on a bank for half an hour or more or watch from a distance with binoculars. But even the wary species will return if they become gradually acclimated to the presence of the motionless observer. As many anglers will attest, you can often see small minnows and darters by walking slowly in streams.

For the more adventurous, a face mask and a snorkel can be used to study fishes in almost every aquatic habitat in Massachusetts. In many areas it is

not necessary to get into deep water. Small hill streams may be cold but offer views of sculpins, trout, and dace. Despite the fact that warmwater ponds and streams are often murky, the world of the Yellow Perch, Pumpkinseed, and Largemouth Bass can be viewed. If you are really lucky, Banded Sunfish, Swamp Darters, and Redfin Pickerel can be seen between the weeds. Safety should always come first. Cold water can lower body temperatures, and many local rivers, streams, lakes, reservoirs, and ponds are littered with dangerous objects ranging from glass to automobiles.

For the less adventurous, it is possible to keep and observe many of our local native fishes in home aquaria. Warmwater species such as catfishes, sunfishes, and killifishes do well indoors and are interesting to watch. Caution should be exercised in selecting what fishes to keep. It is best to have some experience with fishes before bringing any home from the wild because many fishes will feed only on live food and are difficult to keep alive. Local fish and game laws must also be observed, and, in some cases, permits may be necessary. Contact a Massachusetts Division of Fisheries and Wildlife office to obtain the current regulations.

Photographing Fishes Fishes can be photographed either in the wild by swimming with underwater cameras or by placing a fish in an aquarium at streamside. A valid state fishing license or a special permit is required to catch and hold any wild fish. Fishes cannot be moved from the collecting site or released elsewhere without additional permits. Aquaria with gravel bottoms and other natural features can often produce excellent photographs. Strobes should be used to stop action, but all light sources must be set at an angle to the aquaria to prevent reflections.

Technical photographs used to illustrate morphological characteristics generally show a preserved specimen in a uniform, left-sided view without habitats in the background. The fish is placed between a glass plate and the front of an aquarium and photographed. Photographing the fishes in water eliminates surface reflections and allows a record of detailed scales and finrays. Live fishes can be photographed in a similar manner, but care should be taken not to stress the fish. Vegetation and backgrounds can be added to create natural effects.

With the advent of several models of underwater cameras, it is now possible to get into the water and quietly approach your subject. With the proper equipment to keep warm and the patience to move slowly, you can

take good photographs. It is best to swim or crawl upstream so that any silt suspended by your movements will wash away.

REFERENCES. Emery and Winterbottom 1980, Holm 1989, Jenkins and Burkhead 1993 (photography); McDonald et al. 1972 (watching fishes); Mills 1990 (keeping and photographing fishes); Quinn 1990 (keeping native fishes).

The Land, Water, and Fishes of Massachusetts

The Land

The political region we call Massachusetts sits atop an area of New England that is a transition zone between the warm coastal plain to the south and the boreal forest to the north. Due to its geographical position, Massachusetts' physical and natural features are diverse, and its flora and fauna are elements of the ocean, the coastal plain, and the mountains. A wonderful overview of the state's natural biomes is presented in *The Nature of Massachusetts* (Leahy et al. 1996), which includes chapters on aquatic communities such as salt marshes, coastal plain ponds, freshwater marshes, lakes and ponds, rivers and streams, and the floodplain forest, all important to fishes.

Located in the northeastern portion of the United States, Massachusetts covers 8,257 square miles. It is the third most densely populated state in the United States but ranks only forty-sixth in total area. According to the 1993 US census, the 1990 population was over 6 million with an average density of 730 people per square mile. Elevations across the state range from 3,491 feet at Mount Greylock in northwestern Berkshire County to sea level along the shore. The coastal plain of eastern Massachusetts has elevations that are generally less than 250 feet.

The Water

The Major River Drainages The watersheds of Massachusetts can be divided into 9 major basins or drainage areas and 33 smaller drainages (see Figure 4, Map 2, Table 2; Halliwell et al. 1982). An overview of these watersheds, their flora and fauna, and other characteristics can be found in *An Atlas of Massachusetts River Systems* (Bickford and Dymon 1990). Most of the major river drainages in Massachusetts flow from or into other New England states. For example, New England's largest river basin, the Connecticut, originates at the Canadian border and flows south, separating Vermont

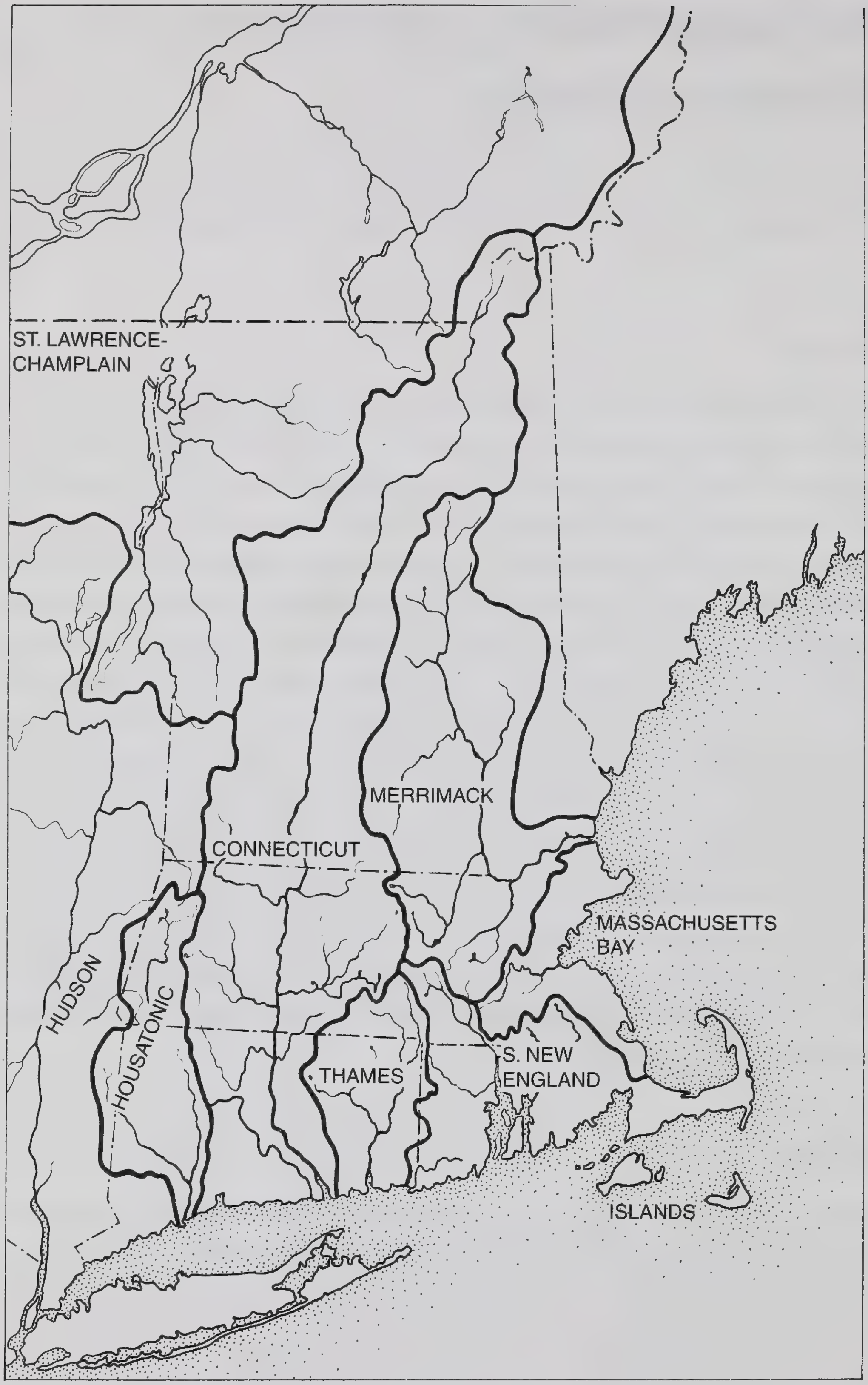
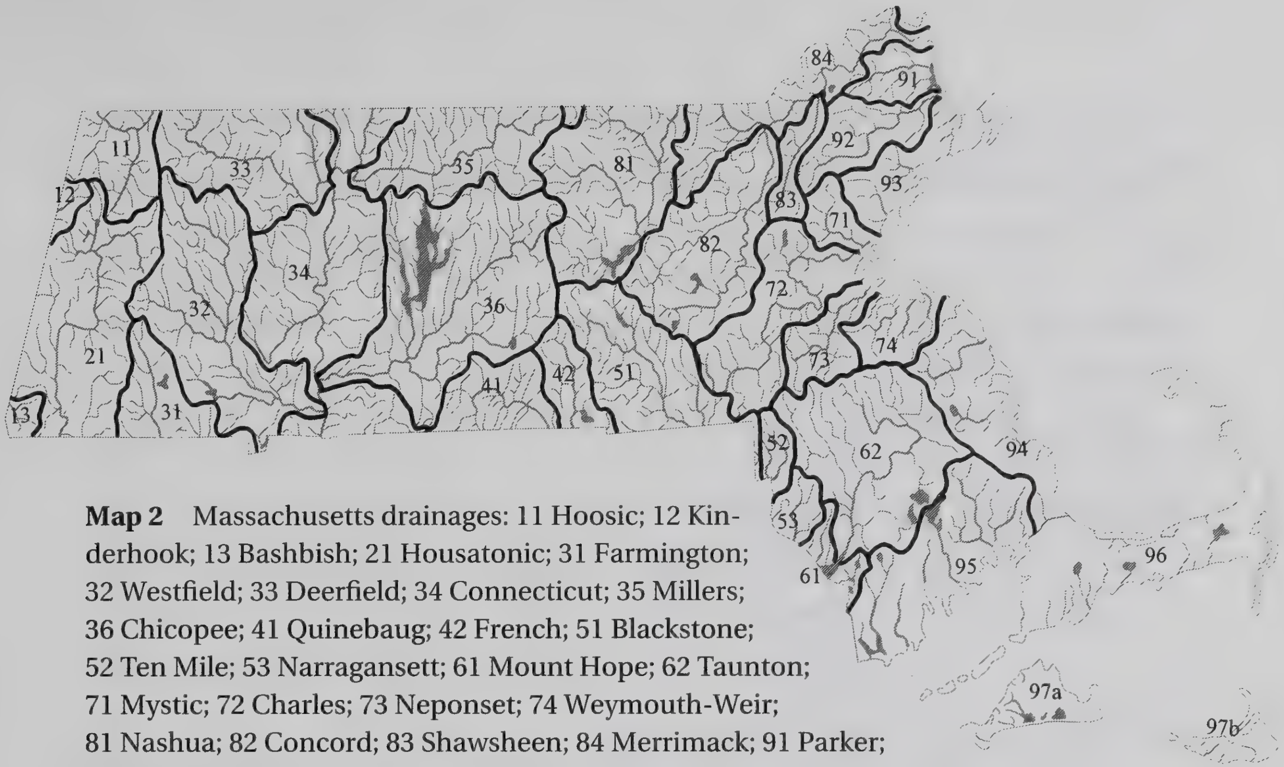


Figure 4. The major drainage basins of New England.



Map 2 Massachusetts drainages: 11 Hoosic; 12 Kinderhook; 13 Bashbish; 21 Housatonic; 31 Farmington; 32 Westfield; 33 Deerfield; 34 Connecticut; 35 Millers; 36 Chicopee; 41 Quinebaug; 42 French; 51 Blackstone; 52 Ten Mile; 53 Narragansett; 61 Mount Hope; 62 Taunton; 71 Mystic; 72 Charles; 73 Neponset; 74 Weymouth-Weir; 81 Nashua; 82 Concord; 83 Shawsheen; 84 Merrimack; 91 Parker; 92 Ipswich; 93 North Shore; 94 South Shore; 95 Buzzards Bay; 96 Cape Cod; 97a Martha's Vineyard; 97b Nantucket (after Halliwell et al. 1982).

from New Hampshire, then moves through Massachusetts and Connecticut, and finally empties into Long Island Sound. In total, there are more than 2,027 streams and rivers that traverse approximately 5,465 miles (8,795 km) in Massachusetts. The Connecticut and Merrimack river basins are the largest, draining 2,726 and 1,200 square miles respectively. The smaller coastal drainages form a large combined watershed that drains approximately 2,352 square miles.

The major Massachusetts watersheds are outlined below and on Map 2. The area of each drainage, the number of ponds, and the surface acreage of the ponds are shown in Table 2.

Hudson River Basin contains the Hoosic, Kinderhook, and Bashbish drainages that flow north and west out of Massachusetts into the Hudson River and then south to the Atlantic Ocean.

Housatonic River Basin originates in western Massachusetts and flows south through Connecticut into Long Island Sound.

Connecticut River Basin includes the Farmington, Westfield, Deerfield, Millers, and Chicopee drainages in Massachusetts. The basin drains south from the Canadian border to Long Island Sound.

Thames River Basin includes the Quinebaug and French drainages in Massachusetts, which flow south through Connecticut to Long Island Sound.

Merrimack River Basin flows south from New Hampshire and contains

Table 2 Massachusetts water resource summary.

Basin	*Drainage*	*Map Code**	*Sq. Miles*	*No. Ponds*	*Acres*
HUDSON	Hoosic	11	166	17	625
	Kinderhook	12	22	4	28
	Bashbish	13	16	5	41
HOUSATONIC	Housatonic	21	500	118	5184
CONNECTICUT	Farmington	31	156	50	3583
	Westfield	32	517	79	4550
	Deerfield	33	347	21	589
	Connecticut	34	669	103	2992
	Millers	35	313	104	4720
	Chicopee	36	723	166	31837
THAMES	Quinebaug	41	154	55	2406
	French	42	95	66	3603
MERRIMACK	Nashua	81	443	161	10953
	Concord	82	400	127	7456
	Shawsheen	83	78	19	552
	Merrimack	84	279	79	4033
MASSACHUSETTS BAY	Parker	91	82	17	316
	Ipswich	92	155	74	1982
	North Shore	93	172	90	2428
	Mystic	71	76	45	1496
	Charles	72	319	142	3708
	Neponset	73	117	61	1879
	Weymouth-Weir	74	91	27	1213
	South Shore	94	241	173	5151
SOUTHERN NEW ENGLAND	Blackstone	51	335	185	7267
	Ten Mile	52	49	42	1301
	Narragansett	53	56	5	146
	Mount Hope	61	56	7	3713
	Taunton	62	530	213	12551
	Buzzards Bay	95	375	171	6378
	Cape Cod	96	403	343	11039
	Islands	97	160	102	7453

*Refers to Map 2

three drainages in Massachusetts. The Nashua Drainage courses north from Massachusetts through New Hampshire, and the Concord Drainage (the combined Concord-Sudbury-Assabet system) and Shawsheen Drainage flow into the Merrimack main stem before it enters the Atlantic Ocean at the northeast corner of Massachusetts.

Massachusetts Bay Drainage Area contains a large assemblage of drainages flowing to the Massachusetts Bay portion of the Gulf of Maine, north of Cape Cod. Included are the Parker, Ipswich, North Shore, Mystic, Charles, Weymouth-Weir, Neponset, and South Shore drainages.

Southern New England Drainage Area is a group of drainages that, with the exception of a few streams on Cape Cod, drain south into Narragansett or Buzzards Bay and Nantucket Sound. Included are the Blackstone, Ten Mile, and Narragansett drainages, all with headwaters in Massachusetts, that flow south through Rhode Island to Narragansett Bay; the Taunton and Mount Hope drainages, completely in Massachusetts, which drain south into Mount Hope Bay; and the Buzzards Bay, Cape Cod, and Island drainages, which include Martha's Vineyard and Nantucket.

The Fishes

Fossil Fishes Fossil fish records from inland New England date back almost 200 million years. Remains of the extinct genera *Semionotus, Redfieldius,* and *Diplurus* (see Figure 5) can be found in sedimentary rocks from huge lakes in what is now the Connecticut River Valley. The genus *Semionotus* is the most commonly found local fish fossil; based on the frequency with which its fossils are seen, this genus existed in large numbers. *Redfieldius,* a more elongate fish, is much less commonly encountered. However, the rarest of all, at least in the Connecticut Valley, is *Diplurus,* a member of the lobe-limbed fish group that some scientists think might have given rise to tetrapods. One species of the lobe-finned fishes, called the Coelocanth, *Latimeria,* is still living today in the deep marine waters of the Indian Ocean.

More recent fossils are absent, primarily because of the nature of New England's geological events. However, based on archaeological information, the Massachusetts fish fauna of 3,000 to 700 years ago probably contained the same fish species as when the Pilgrims arrived. Scarce records from archaeological sites, usually fragments of scales, vertebrae, otoliths, or, rarely, pharyngeal and buccal jaw elements, indicate that the Native Americans ate sturgeons, river herrings, Chain Pickerel, Fallfish, and Brook Trout.

REFERENCES. Colbert 1970; Olsen 1980; Olsen and McCune 1991.

Recent Fishes Currently 83 species of fishes, both native and introduced, from 27 families have been documented as regular residents of Massachu-

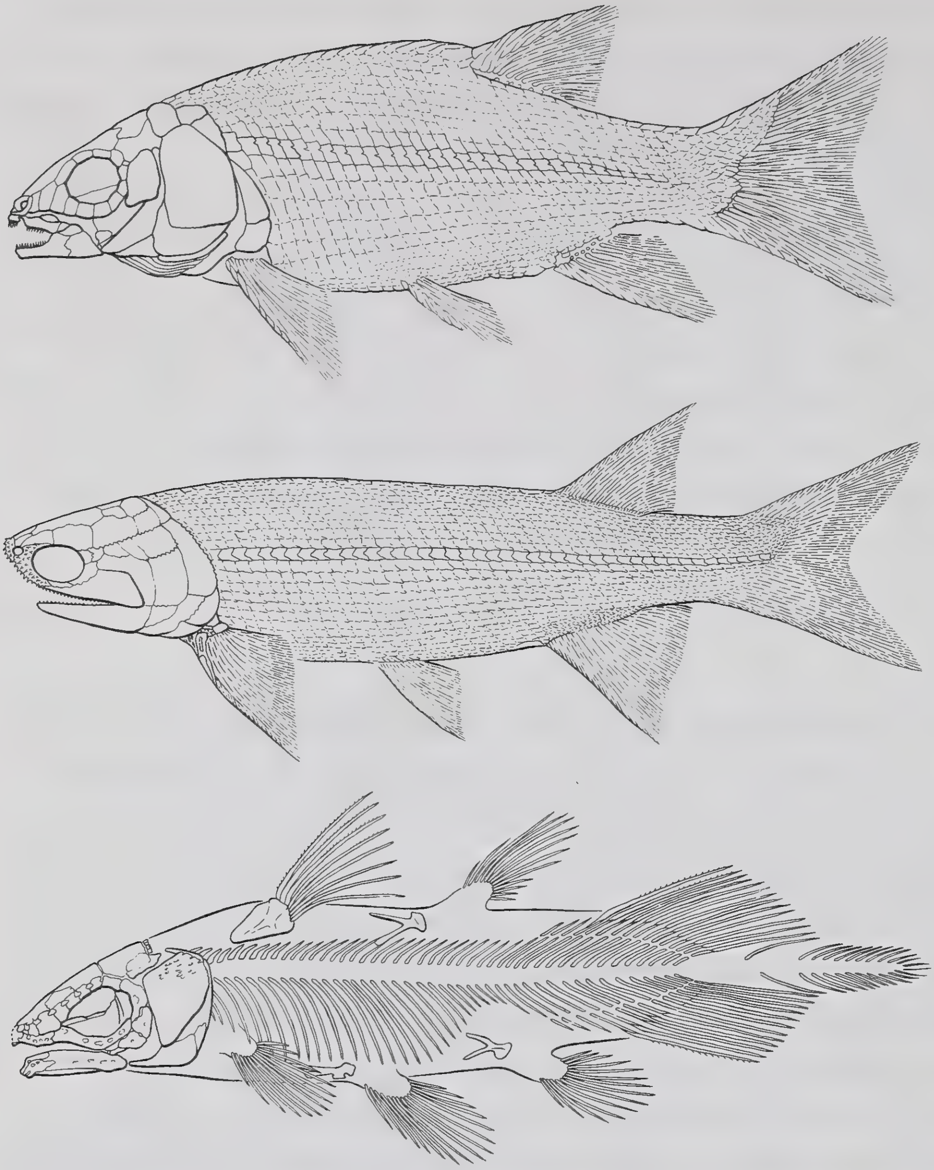


Figure 5. The Connecticut River Valley fossil fishes. Top: *Semionotus* (redrawn from Olsen and McCune 1991). Middle: *Redfieldius* (redrawn from Schaeffer and McDonald 1978). Bottom: *Diplurus* (redrawn from Schaeffer 1952).

setts freshwaters (see Table 3 and Appendix 2). This book outlines all species that permanently live in freshwater and also those that usually move between fresh- and saltwater during various stages of their life histories. It does not cover the occasional vagrant marine species that sometimes enter the edge of freshwater.

The species treated in this book can be separated into three ecological groups: 1) primary freshwater fishes that live their entire life cycles in freshwater; 2) secondary freshwater fishes that have the physiological capacity

Table 3 Number of reproducing species per drainage basin.

Basin	*Primary*	*Secondary*	*Introduced*	*Diadromous*	*Total*
Hudson	15	0	8	0	23
Housatonic	22	0	16	0	38
Connecticut	26	1	26	7	60
Thames	17	0	14	0	31
Merrimack	21	8	18	10	57
Mass. Bay	18	12	12	9	51
S. New England Islands	19	18	12	10	59
Islands	11	17	2	4	34
State Total	29	18	27	10	84

to move back and forth between salt- and freshwater; and 3) diadromous fishes that make relatively long seasonal migrations between salt- and freshwater. Most diadromous fishes are anadromous; like the herring and salmon, they are born in freshwater, grow at sea, and migrate to freshwater as adults to spawn. The American Eel is catadromous, with a life cycle the reverse of the salmon and herring. Eels are born at sea, return to freshwater to grow, and then re-enter the sea to spawn and die. Table 3 shows the relative numbers of species from each group found in each drainage.

Two native fishes have been extirpated from the Massachusetts portions of their range. First, the Atlantic Salmon, although currently being reintroduced, disappeared in the mid-1800s after the construction of dams. The second species, the Trout-perch, was known from the Hoosic and Housatonic drainages and was last found in the early 1940s.

Surprisingly, 48 percent of Massachusetts primary fish species are not native to the state but were introduced and are now reproducing in local waters. These species are mostly game fishes and include black basses and sunfishes, pike, and several catfishes, which were introduced to enhance sportfishing. Other non-native species include some minnows that escaped or were released from baitbuckets. In fact, the introduced Bluntnose Minnow, unknown from Quabbin before 1984, was the most abundant shorefish in the reservoir during our autumn surveys in 1989. The 27 exotic species now reproducing in Massachusetts are treated in detail in the species accounts.

In addition, a fair number of nonreproducing exotic species have been reported from local waters (Hartel 1992, Cardoza et al. 1993). Reports of

non-native North American species include a few observations of a true gar, probably the Spotted Gar, *Lepisosteus oculatus,* one record of a Northern Hog Sucker, *Hypentelium nigricans,* and three species of minnows, including Emerald Shiner, *Notropis atherinoides,* Grass Carp, *Ctenopharyngodon idella,* Red Shiner, *Cyprinella lutrensis* (Hartel 1992), and Mosquitofish, *Gambusia affinis.* The following fishes from outside North America have all been found in Massachusetts: the pacu-like Pirapatinga, *Piractus brachypomus,* and tambaquí, *Colossoma macropomum,* which are both from South America; the Grass Carp, *Ctenopharyngodon idella,* and Walking Catfish, *Clarias batrachus,* from Asia; the Oscar, *Astronotus ocellatus,* from South America; the Midas Cichlid, *Cichlasoma citrinellum,* from Central America; the Giant Snakehead, *Channa micropeltes,* from Asia; and one of the African Upside-down Catfishes, *Synodontis.* Most surprising, more than a dozen documented records (and other verbal reports) of the Red Piranha, *Pygocentrus nattereri,* have been brought to our attention over the last decade. Almost all of these fish were caught by anglers and brought to the Massachusetts Division of Fisheries and Wildlife or the Museum of Comparative Zoology for identification. Fortunately, most of these exotic fishes cannot survive winter water temperatures. However, a second species of Asian shakehead, *Channa argus,* was collected live from Newton Pond, Shrewsbury, in 2001. This species ranges quite far north in Asia and could survive Massachusetts winters.

Non-native or exotic fishes, those introduced from outside their native drainages, from both near and far, have been involved in the decline of many native species worldwide (Courtenay and Stauffer 1984). The exotic fishes found in Massachusetts are mostly released aquarium pets, but some, like the Grass Carp, were the result of deliberate, though illegal, introductions.

Origin and Distribution of the Fauna

The origin of native fishes found today in Massachusetts can be traced back to a period just after the last glaciers receded from the Northeast around 14,000 years ago. These large bodies of ice covered the Northeast for about 70,000 years and made the survival of freshwater vertebrates impossible. All traces of the fish species that lived here shortly before the glaciers have been lost to time. However, by understanding the geological events and the geographical ranges of native North American species, we can postulate how

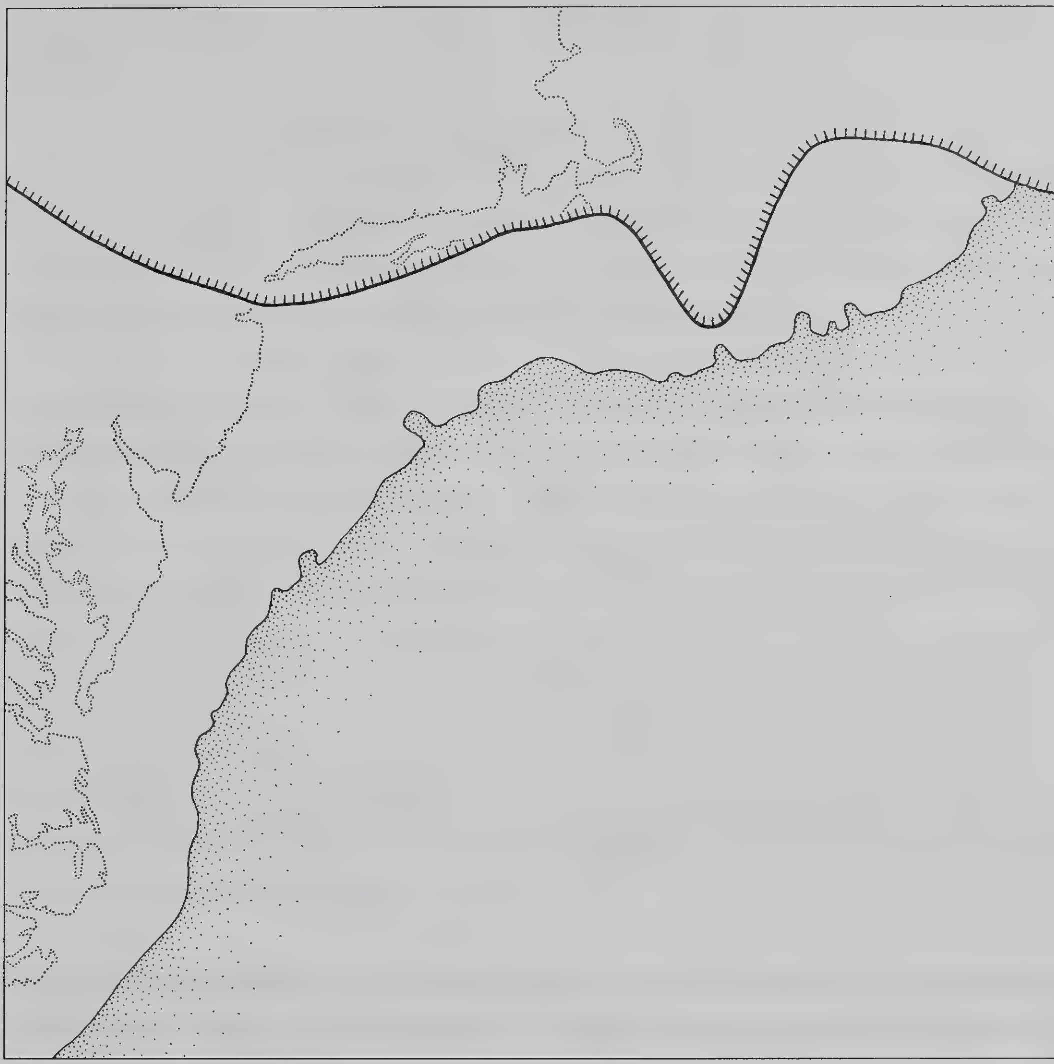


Figure 6. The glaciated Northeast about 14,000 YBP. Dotted line shows the present coastline; a solid line indicates the coastline at that time; and a solid line with perpendicular bars shows the extent of glaciation (adapted from Emery 1987).

freshwater fishes moved into New England as the glaciers melted and retreated to the north.

As the glacial ice retreated, Cape Cod and the islands of Martha's Vineyard and Nantucket were formed from the material that accumulated at the edges of the glaciers. The sea level dropped almost 100 feet during maximum glaciation, and large areas of exposed continental shelf formed a broad coastal plain along eastern North America (see Figure 6) that contained abundant streams created by glacial melt. Mastodons and mammoths roamed this coastal plain, part of which is now Georges Bank.

Ancestors of the native species found in Massachusetts today survived the glacial period in areas south of the ice. These areas, called "refugia,"

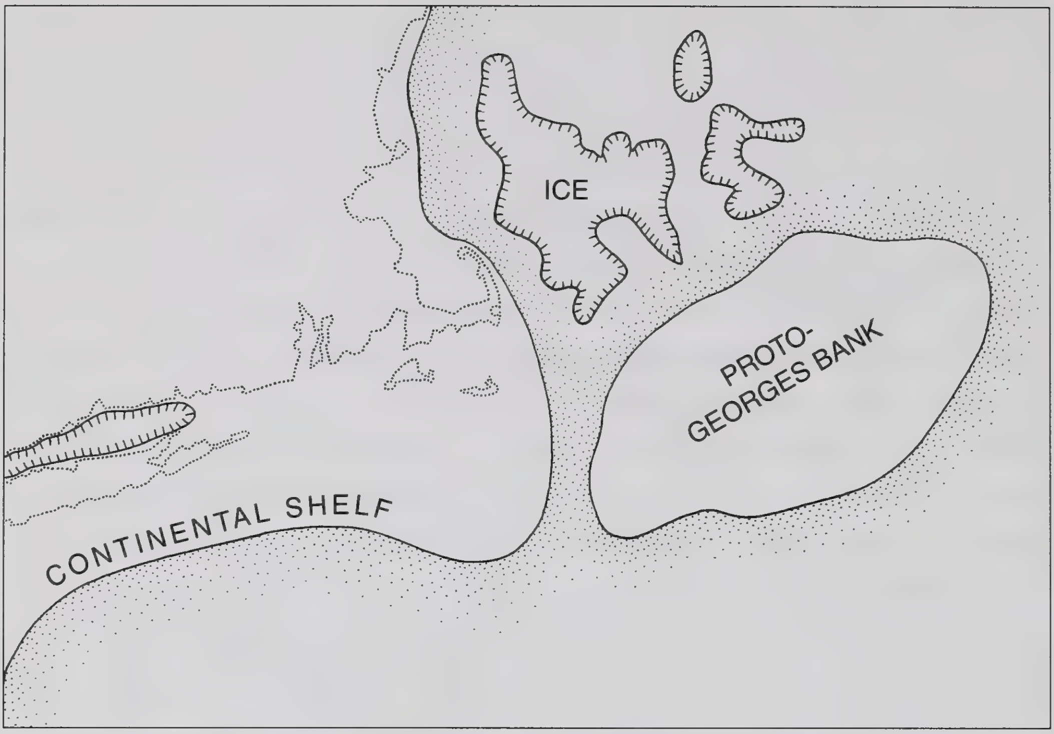


Figure 7. The receding glacier about 11,500 YBP. Proto-Georges Bank is an island; ice blocks are present at what will be Long Island Sound and near Stellwagen Bank (adapted from Schmidt 1986, Emery 1987).

allowed the genetic stocks to survive and spread into areas once covered by ice. The routes that the fishes employed in populating Massachusetts pose intriguing questions.

The Southern Invasion The current distribution pattern of fishes along the Atlantic coastal plain indicates that the majority of Massachusetts freshwater fish species survived the glacier in refugia along the coast, possibly as far south as North Carolina (Schmidt 1986), or in areas off the present Connecticut coast (Whitworth 1996). A northern coastal refugium in the vicinity of Georges Bank has also been suggested, and this area might account for some of the forms found on Cape Cod and the Islands. At various times, Georges Bank was a cape (14,000 YBP) or an island (11,500 YBP; see Figure 7) that may have harbored isolated populations of plants, invertebrates, or vertebrates in southern New England (D.G. Smith 1992, pers. comm.; Schmidt 1986: 148). Variation in some northern forms of estuarine fishes, such as Mummichogs, Rainwater Killifish, and Inland Silversides, may be related to this phenomenon.

It is postulated that, as temperatures moderated, fishes from the refugia

gradually migrated into New England rivers and streams. They invaded inland to all areas except where physical or ecological barriers, such as waterfalls, stopped their passage. Some species, such as the Swamp Darter and Banded Sunfish, were possibly prevented from entering some of the southern New England drainages by a giant residual ice block thought to be present in what is now Long Island Sound (Schmidt 1986) or by the rise of salt water into glacial Lake Connecticut (Whitworth 1996).

The Northern Route The distribution of a few northern New England fishes seems to be most closely linked to the Great Lakes fauna, which survived glaciation in the Mississippi Valley. Although there is little geological evidence to support the theory or indicate the actual route followed, it is likely that species, such as the Redbelly Dace, followed glacial streams, bogs, and flooded lakes that probably linked the precursors of the upper Hudson and Saint Lawrence basins to today's Connecticut River Drainage and other areas of northern New England. Once into the upper headwaters of the Connecticut, their route into Massachusetts would have been easily accomplished. Species such as the Lake Chub, Burbot, and Trout-perch may also have arrived from the north.

Current Distribution The recent distribution of fishes in Massachusetts is shown on the maps found adjacent to each species account and summarized in Appendix 2. The numbers of native primary species historically known from the larger Massachusetts drainage basins range from 21 to 26 (see Table 3), whereas the medium-sized drainage areas have only 15 to 19. The islands of Martha's Vineyard and Nantucket have far fewer native primary species, and it is difficult to prove which of those on the islands are native or transplanted from the mainland. The numbers of species per drainage area and the species composition are, in part, related to historic geology in that some species just were not able to migrate into drainages having appropriate habitats. However, certain regions, like parts of the Massachusetts Bay Drainage Area, have certainly lost species due to factors related to urbanization. No clear-cut zoogeographic pattern emerges from this simple analysis except that a few coastal plain species, such as the American Brook Lamprey, Redfin Pickerel, and Banded Sunfish, are not found in the western part of the state. Conversely, the Redbelly Dace, Lake Chub, Eastern Silvery Minnow, Creek Chub, Longnose Sucker, and Trout-perch are found only in the western areas. Others like the Slimy Sculpin,

Blacknose Dace, Longnose Dace, and Fallfish are common to the west but show strong indications that they were more widely spread to the east in recent historic times.

The only clear differentiation is in the number and distribution of native secondary species, with more species found in the Southern New England Drainage Area. There are about twice as many native secondary species south of Cape Cod, especially if the Bay Anchovy and Inland Silverside, which are rare north of the Cape, are considered part of the southern fauna. This faunal break follows a well-documented distributional pattern for marine fishes where many mid-Atlantic species are not found north of Cape Cod or Georges Bank.

Explanations of how or why species are found in some drainages and not in others are difficult. The problem lies in interpreting current distribution data that have gaps and misleading information due, at least in part, to human involvement during the last four centuries. Eighteenth-century extirpation, transplantation, or movement through built canals from drainage to drainage confuse the data. In addition, the fact that comprehensive surveys of the state's freshwater fauna were not made until the 1940s does not allow the establishment of baseline data on which to evaluate patterns of distribution.

REFERENCES. Raymo and Raymo 1989 (New England geology); Schmidt 1986, Whitworth 1996 (New England fish zoogeography); Emery 1987 (Georges Bank).

How to Use This Book

Identifying Fishes

As in animal tracking or birdwatching, looking at fishes requires the development of good powers of observation. However, since there are relatively few species of fishes in Massachusetts, identification is somewhat simplified. One method is to look at illustrations or color plates and match them with a fish. Careful attention should be paid to the number, size, and placement of the fins as well as to the size of the scales, the general body shape, and color pattern. The various features of a fish are diagrammed in Figure 8. A review of the distribution maps and the descriptions of habitats should also help in identification by eliminating some species. After matching a fish to an illustration, the next important step is to read the identification section as it outlines each species' salient features.

The best way to identify a fish is to use the identification keys. The family key (page 51) will identify a fish to its family and will direct the reader to a species key. If only one member of a family occurs in Massachusetts, the family key will identify it directly to the species.

Identification keys in this book are presented in pairs of illustrated statements called "couplets." Each part of a couplet gives one or several choices, which are opposite those given in the other part of the couplet. For example, the "a" part of the couplet might state that the fish has an adipose fin, while the "b" part of the same couplet states that the fish lacks such a fin. The reader chooses the one that best describes the fish to be identified. The key then leads to another couplet and ultimately to the correct identification. Careful reading of the couplets is essential.

Special equipment is not necessary, although a hand lens or an inexpensive microscope may be needed to identify smaller fishes, particularly minnows. In addition, a small probe or a large needle will help to count or separate features such as fin rays, gill rakers, or scales.

Uniform and accurate counts and measurements are important in identifying fishes. The standard methods of measuring fishes described by Hubbs and Lagler (1964) and Jenkins and Burkhead (1993) are followed in this book. We have kept terminology and the types of counts and measurements to a minimum in the keys and identification section. A section with selected counts containing key information is given at the beginning of each species account (the counts are principally from reviews of Trautman 1981, Scott and Crossman 1973, Smith 1985, and Jenkins and Burkhead 1993). For a full set of counts and measurements, C.L. Smith's *The Inland Fishes of New York State* (1985) covers most of the Massachusetts species. Under selected counts, the following abbreviations are used: D=dorsal fin, A=anal fin, GR=gill rakers, Pec=pectoral fin, Pel=pelvic fin, PT=pharyngeal teeth, Vert=vertebrae. Scales are usually indicated by three sets of numbers separated by forward slashes. They indicate scales above the lateral line/scales along the lateral line/scales below the lateral line. Uppercase Roman numerals indicate true spines, lowercase Roman numerals indicate spinelike soft rays, and Arabic numerals indicate true soft rays.

General Anatomy

The overall anatomy of the body parts of a fish is presented in Figure 8, with two fishes to illustrate most of the body parts mentioned in this book. In addition, the head is shown in detail to demonstrate its parts and the gill arch structure, which can be seen by lifting the gill cover.

Measurements

As shown in Figure 8, there are two common ways of measuring fishes. The most common is total length (TL), often used by anglers and fisheries biologists. Total length is the maximum length of the fish from the furthest projections of the jaws or snout to the tip of the tail. The other type, called standard length (SL), is used for more precise measurements. With this system, the fish is measured from the tip of the upper jaw to the base of the bony plate that supports the tail fin. This point on the tail often shows a crease in the skin when the tail is bent. Standard length allows the accurate measurement of fishes even when the tail is damaged. Head length (HL) is measured from the tip of the upper jaw to the posterior edge of the gill cover.

Counts

Rays and Fin Spines The elements supporting the fins are generally of two types, either soft rays or hard spines (see Figure 8), which can be counted easily by placing a light behind the fin.

Soft rays are usually, but not always, branched and flexible. Most rays are bilaterally paired and segmented. Occasionally, soft rays are hard structures, as in the spines of carp or catfishes, and are often called spines but are actually hardened soft rays. They can always be identified as rays if they are divided, branched, or segmented. Soft rays can usually be easily counted by following these rules: In minnows (Cyprinidae), suckers (Catostomidae), and trout (Salmonidae), only the principal rays are counted. These include the single, large, unbranched ray at the front of the fin and the remaining branched rays. In catfishes (Ictaluridae) and a few other groups, with fins that taper forward and result in small anterior rudimentary rays, all rudimentary rays are counted; and, in catfishes, the skin along the base of the anal fin often has to be removed to expose the small rays. Always count the last two rays of the dorsal fins as one when they are joined together at their bases.

Fin spines are unsegmented and usually hard and sharp but may be flexible as in the sculpins (Cottidae). All spines are counted, even the smallest.

Scales Scale counts are often the only way to separate closely related species, and accurate counts can usually be made only on preserved material. For small fishes, a microscope may be needed, and it is best to let the scales dry slightly to see the scale edges. Another method is to direct a small jet of air at each scale as it is counted, using a hollow needle on a rubber hose connected to a small aquarium pump.

Lateral-line scale counts are made along the lateral line or along the midbody of a fish that does not have a lateral line. The lateral line is a sensory system, and scales along it have a pore or tube that leads to a sensory device. Counts start at the posterior end of the opercle and end at the base of the caudal fin. The base of the caudal fin is the area where a crease forms when the tail is folded back and forth.

Scales above the lateral line are counted diagonally, downward, and backward, in a row from the dorsal fin origin to the lateral line. The count follows the natural row of scales and includes the small scales at the base of the dorsal fin, but not the lateral-line scale.

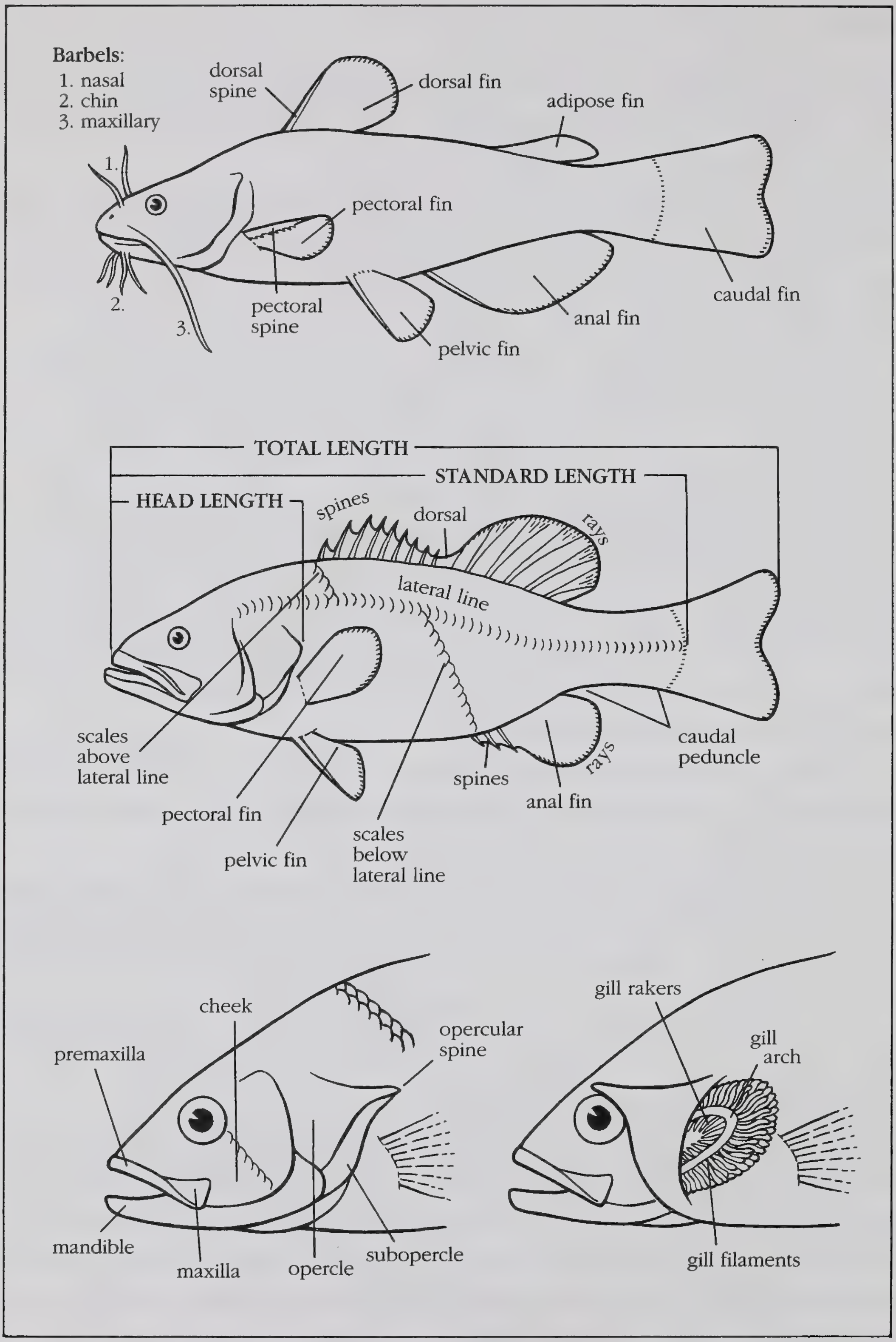


Figure 8. General anatomy of a fish.

Scales below the lateral line are counted upward and forward from the beginning of the anal fin.

Scales before the dorsal fin are counted along the midline of the back from the origin of the dorsal fin to the area at the rear of the head where the scales stop. All scales that intercept the midline are counted.

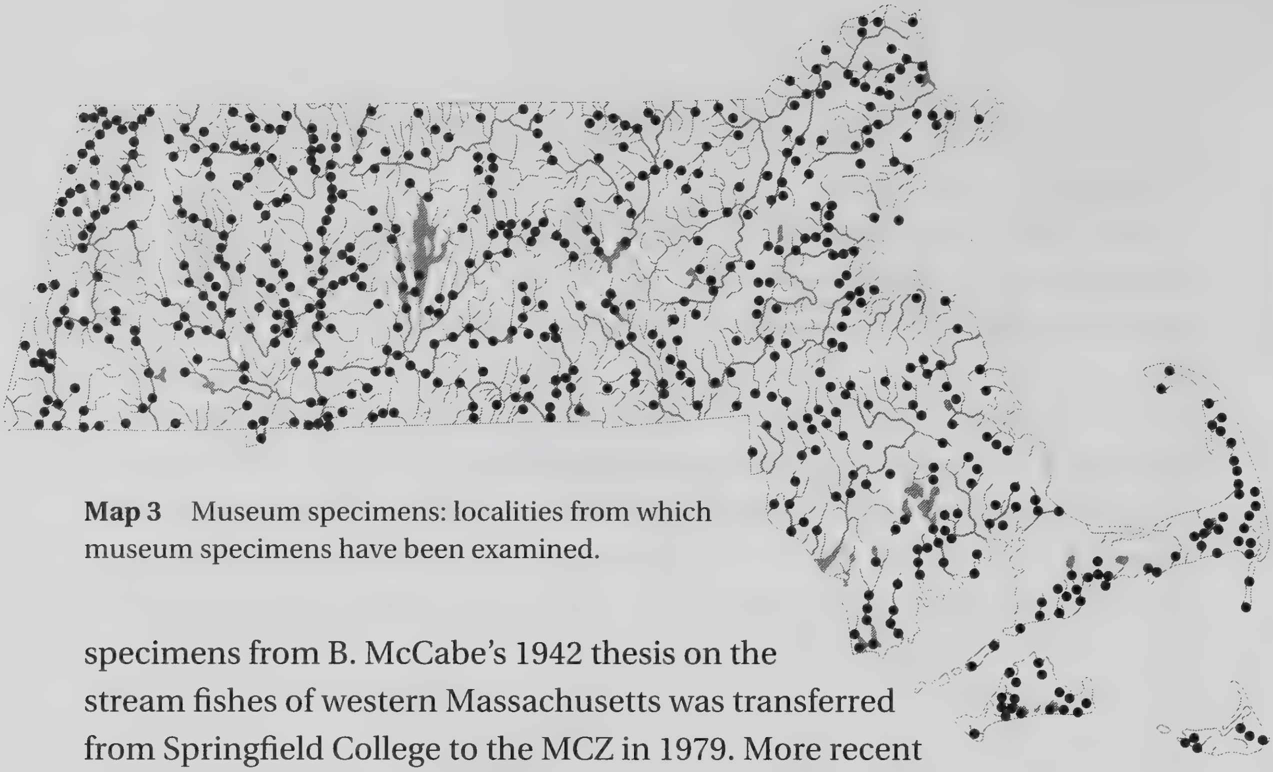
Gills Gill rakers, the structures on the anterior surface of the gill arch, should not be confused with the gill filaments, which are used for respiration and are found on the posterior gill arch (see Figure 8). The gills can be observed by lifting the opercular flap, which may have to be cut open along the bottom in some fishes (especially catfishes). Gill raker counts usually include all of the rakers, even the smallest most rudimentary ones, on the first gill arch. However, in some cases, the keys will indicate that a count of only the rakers on the lower half of the arch is required.

Interpreting the Distribution Data

Information about the distribution of Massachusetts fishes is the key part of this book. These data, represented on the maps, are based on examination of museum specimens, field surveys, and literature. The original data for these maps are available for examination at the Museum of Comparative Zoology, Harvard University, or at the Field Headquarters of the Massachusetts Division of Fisheries and Wildlife, Westborough.

Museum Specimens Well over 50,000 museum specimens were examined to verify fish identifications and distribution. A few at the Museum of Comparative Zoology date back to the mid-1800s, but most were collected after 1950. Museum specimens form the most solid database, especially for the smaller, more difficult to identify species. Specimens used in this study are stored principally at the Museum of Comparative Zoology, Harvard University (MCZ), and the Museum of Zoology, University of Massachusetts, Amherst (UMA). Additional material at Northeastern University, Boston; Southeastern Massachusetts University, Dartmouth; the University of Michigan, Ann Arbor; Fitchburg State College; and Cornell University, Ithaca, was also examined. Map 3 shows the areas from which the museum specimens were collected.

The MCZ has some older specimens collected by D.H. Storer, W.H. Putnam, R.H. Wheatland, and S.F. Baird from the mid-1800s. A small series of



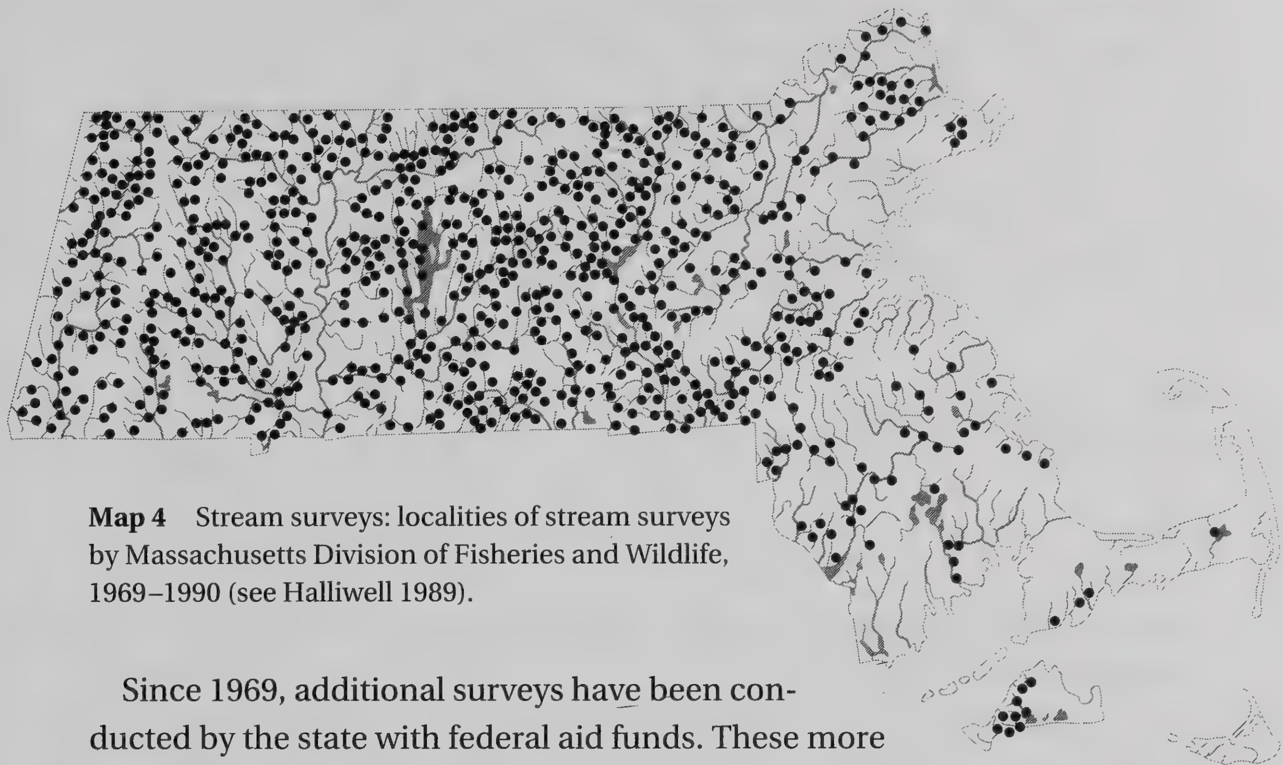
Map 3 Museum specimens: localities from which museum specimens have been examined.

specimens from B. McCabe's 1942 thesis on the stream fishes of western Massachusetts was transferred from Springfield College to the MCZ in 1979. More recent accessions include R.H. Gibbs' Boston University collections from the early-1960s and a large amount of material collected by K.E. Hartel, principally with C.R. Gougeon, D.G. Smith, T.J. Andrews, and A.E. Launer, between 1975 and 1989. A large number of voucher specimens from the statewide surveys by D.B. Halliwell and other Massachusetts Division of Fisheries and Wildlife (MDFW) workers (1977–1990) have also been deposited at the MCZ.

The collections at the University of Massachusetts, Amherst, were made almost single-handedly by Prof. T.J. Andrews from 1948 to 1980, and some newer material has been acquired by D.G. Smith, since 1974. The University of Massachusetts museum contains some of the best reference material from western Massachusetts.

Fisheries Surveys In addition to museum specimens, MDFW field surveys have helped document distribution. The early surveys were designed primarily to sample game fishes, but, in some cases, information on selected nongame fishes was also included; later survey work routinely listed all fish species encountered.

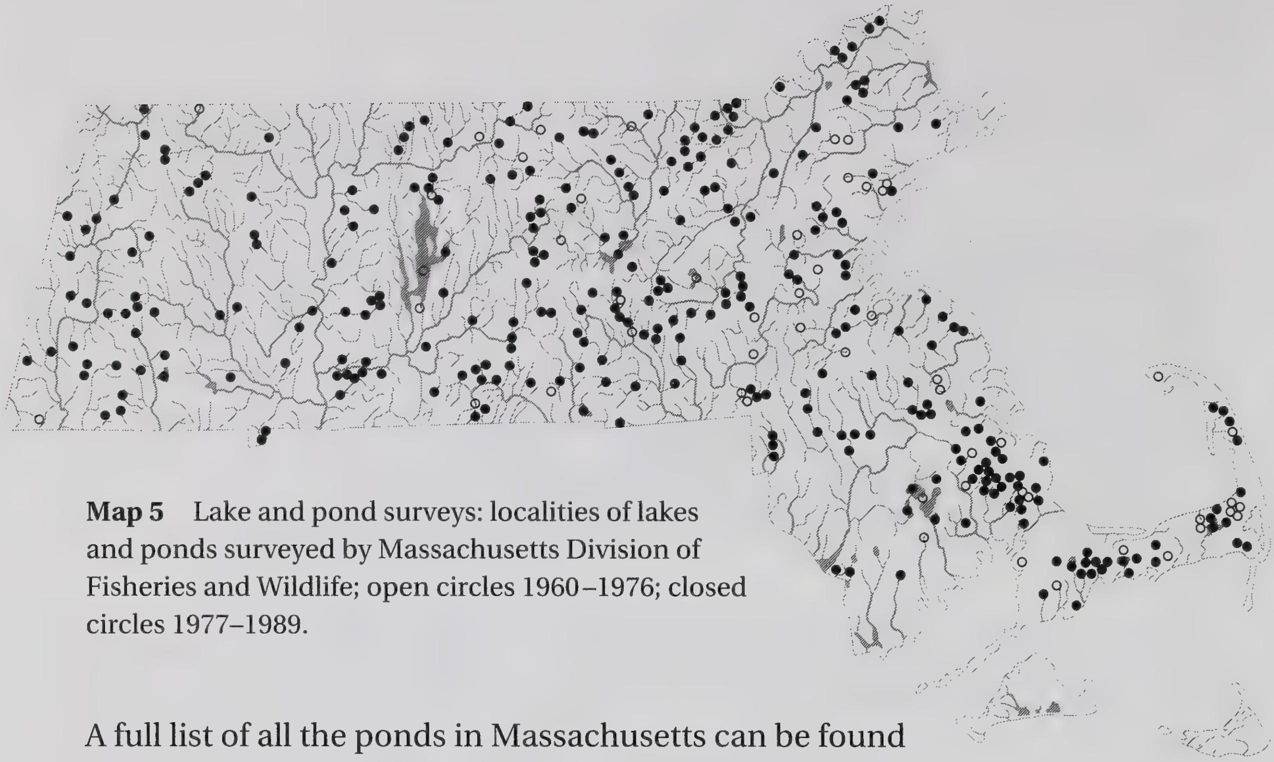
Stream and River Surveys Britton McCabe's work (1942, 1943, Map 1) on the stream fishes of the Hudson-Hoosic, Housatonic, and Connecticut drainages began a series of stream surveys that include the Westfield River (Mullan 1952); the Millers and Squannacook (Mullan 1953); the Merrimack-Ipswich (Schlotterbeck 1954); and the Taunton-North (Bridges 1955). A summary of these surveys was completed by Tompkins and Mugford (1964).



Map 4 Stream surveys: localities of stream surveys by Massachusetts Division of Fisheries and Wildlife, 1969–1990 (see Halliwell 1989).

Since 1969, additional surveys have been conducted by the state with federal aid funds. These more recent surveys (Map 4) include the Charles (Bergin 1969); Housatonic (Bergin 1970); Chicopee (Bergin 1972); Blackstone (Bergin 1973a); Deerfield-Green (Bergin 1973b); Nashua (Madore 1974); Taunton (Madore 1975); Hoosic and Farmington (Madore 1976); and Westfield (Halliwell 1978). A statewide stream survey and classification project was initiated by the MDFW in 1979. During this study, records from 1,430 collections made at 691 streams statewide were analyzed and form the basis of a Ph.D. dissertation by D. Halliwell (1989).

Lake, Pond, and Reservoir Surveys The first set of lake and pond surveys was conducted by the MDFW from 1942 to 1952 and covered 385 lakes statewide (Swartz 1944; McCabe 1948, 1952, 1953; McCabe and Swartz 1952; Stroud 1955; Map 5). Along with the surveys from 1952 to 1968, 76 lakes across the state were chemically treated to remove unwanted fish species and facilitate trout management. Additional MDFW surveys covering another 385 lakes (436 samples) were carried out between 1960 and the early 1990s, but these studies were not published. However, selected information from these surveys is available in pond booklets printed by the Massachusetts Division of Fisheries and Wildlife. These booklets include pond maps and are available at minimal cost from the division's Westborough Field Headquarters. Data based on both the published pond data and the unpublished field data were compiled, reviewed, and used for this book.



Map 5 Lake and pond surveys: localities of lakes and ponds surveyed by Massachusetts Division of Fisheries and Wildlife; open circles 1960–1976; closed circles 1977–1989.

A full list of all the ponds in Massachusetts can be found in Ackerman et al. (1984).

Between 1991 and 1996, an additional 27 Massachusetts lakes were monitored by the US-EPA Environmental Monitoring and Assessment Program (Whittier et al. 1997).

Coastal Rivers and Estuaries Data for distribution of upper estuarine species have been obtained from a review of the bay and estuary surveys of the Massachusetts Division of Marine Fisheries that were published in their Monograph Series between 1965 and 1975. Clayton et al. (1978) reviewed data for many coastal species using both published and unpublished data, including a summary of these surveys.

Distribution Maps Each symbol on a map represents a locality from which we have seen specimens or carefully reviewed reports and literature accounts. A single symbol may represent several closely situated sites. Most records are of museum specimens or from MDFW field surveys; in most cases, marine records are not shown. On some maps, two types of symbols are shown to give information, as explained in the caption under the map. Solid or open circles are most often used to show the presence or absence of a species in recent surveys. In maps that present this information, the solid symbols represent all verified records; however, many of these sites were sampled only once, possibly many years ago. Open circles show sites where a species was documented before 1970 but where it was not found when resampled during recent studies (1975–1991). Several open circles,

especially if clumped together, may indicate loss of a species from that area or an environmental problem. However, these data should be interpreted cautiously because of possible sampling errors.

OVERVIEW AND OUTLINE OF FAMILY AND SPECIES ACCOUNTS

Family Accounts

Each family account outlines a group of closely related species. Scientific names of families always end in the suffix "idae." The sunfish family, Centrarchidae, the pike family, Esocidae, and the salmon family, Salmonidae, are three examples. The family accounts provide general information on such topics as worldwide distribution, relationships to similar fishes, and the number of species in the family. Technical terms are defined in the glossary (Appendix 3).

Species Accounts

These sections give the common and scientific names of the species, their conservation status, a line drawing, and a reference to the appropriate color plate. Also included are sections on identification, size, natural history, distribution and abundance, special notes, and references.

Names. Names used in this book generally follow those suggested by the American Fisheries Society's *Common and Scientific Names of Fishes from the United States and Canada* (Robins et al. 1991a), except when changes have been published since that release. The common name of each species appears on the first line of each species account. Below it is the scientific name, consisting of two words, first the generic and then the specific name. These names are always italicized in print. Following the species name is the name of the person who described the species, along with the date of the description. When the describer's name and date appear in parentheses, it indicates that the species is now placed in a different genus from the original description. Scientific names for the fish species treated in this book are not given in the text because they are noted at the beginning of each species account. However, species that are not treated in this book have the scientific name used each time they are mentioned.

Species Status. At the beginning of each species account the status of each species is given. These categories (native or introduced) are based on documented introductions, literature reviews, and our interpretation of each species' distribution in North America. Also, the status of rare species (special concern, threatened, or endangered) is noted at the head of each species account.

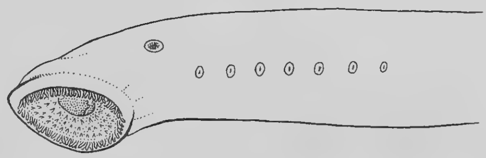
Size. Information on total length (TL), measured in inches, is given in all accounts. In some accounts, we supplement TL with a metric standard length (SL) to document or clarify records.

Distribution and Abundance. This section describes the state and local range, as well as general abundance, and includes a map for each species. Information on the total range of these species is available in Lee et al. (1980 et seq.) and in Page and Burr (1991). For an explanation of distribution data and symbols on maps, see page 43.

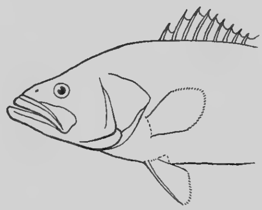
Identification Keys and Species Accounts

Key to the Families and Monotypic Species of Massachusetts Inland Fishes

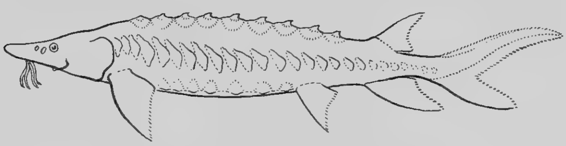
1a. Jaws absent (mouth is an "oral disk"); pectoral fins absent; seven gill openings on each side of head. Lamprey family, Petromyzontidae, page 60.



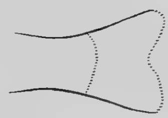
1b. Jaws present (may be modified into "sucker mouth"); pectoral fins present; one gill opening on each side of head. Go to 2.



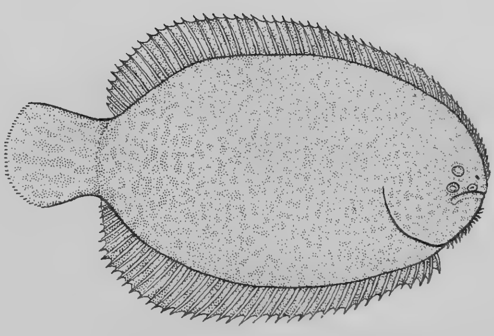
2a. Caudal fin strongly asymmetrical; several rows of bony scutes along body. Sturgeon family, Acipenseridae, page 66.



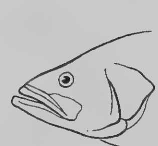
2b. Caudal fin roughly symmetrical, lower lobe less pronounced; if bony scutes present, they are found in one row along midbody line. Go to 3.



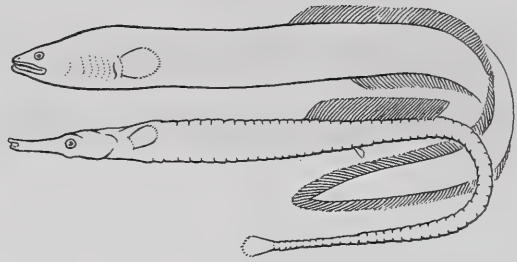
3a. Both eyes on same side of head; body extremely flattened. American Sole family, Achiridae. One local species: Hogchoker, *Trinectes maculatus,* page 280, Plate 55.



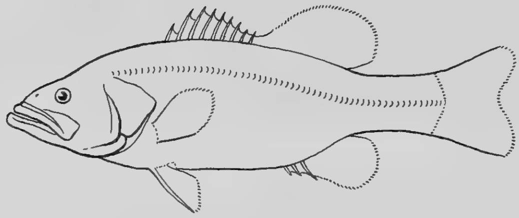
3b. Eyes on opposite sides of head; body not extremely flattened. Go to 4.



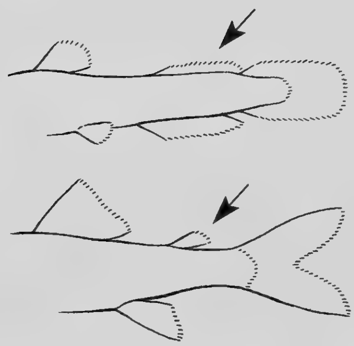
4a. Pelvic fins absent; body very elongate. Go to 27.



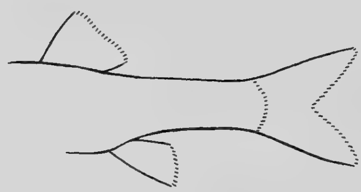
4b. Pelvic fins present; body sometimes slightly elongate. Go to 5.



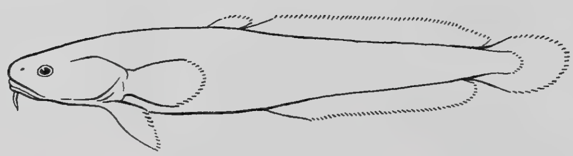
5a. Fleshy adipose fin present. Go to 15.



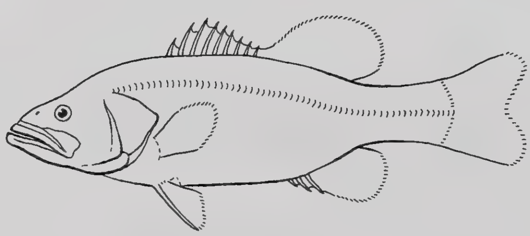
5b. Adipose fin absent. Go to 6.



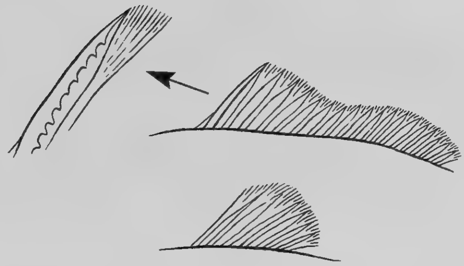
6a. Single median barbel on underside of lower jaw. Cod family, Gadidae, page 189.



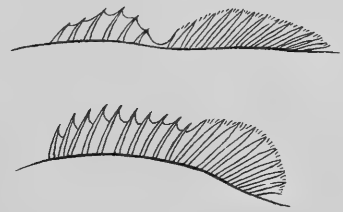
6b. Barbels, if present, are paired on either side of jaws. Go to 7.



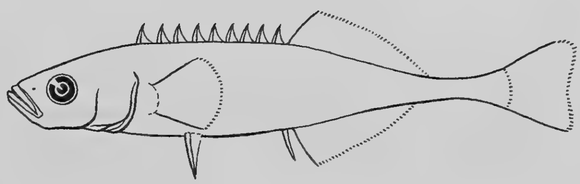
7a. Single dorsal fin with either no spines or with one serrated "spine" at anterior edge; no pelvic spines. Go to 18.



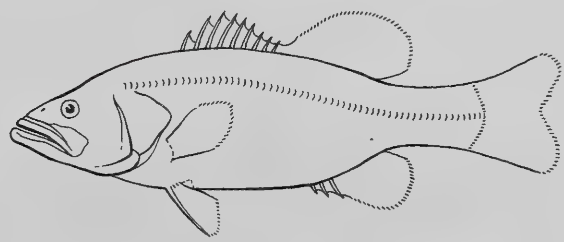
7b. Either one dorsal fin with distinct "spine" and "ray" portions or two distinct fins (first may be series of "free spines"); pelvic fin with one or more spines. Go to 8.



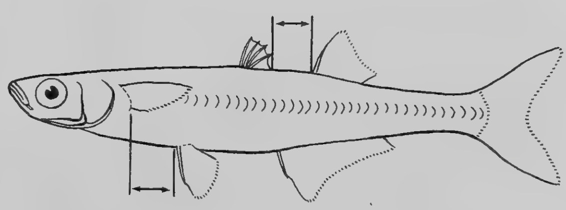
8a. First dorsal fin consisting of series of "free spines." Stickleback family, Gasterosteidae, page 219.



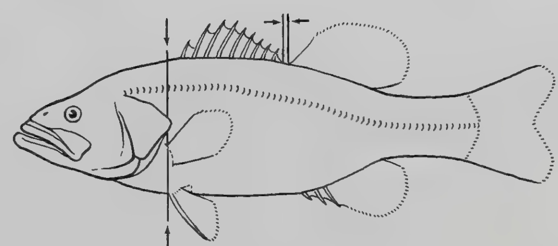
8b. Spines in first dorsal fin connected by membranes. Go to 9.



9a. First and second dorsal fins separated by distance equal to or greater than the length of the base of the first dorsal fin; origin of pelvic fins well behind base of pectoral fins. Go to 14.

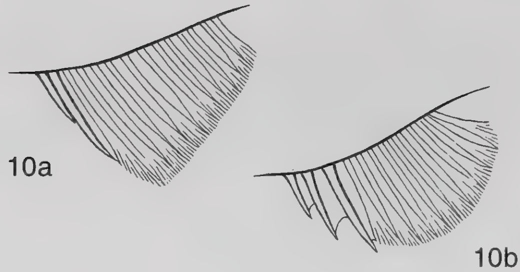


9b. First and second dorsal fins separated by distance less than the length of the base of the first dorsal fin, or are united; origin of pelvic fins directly below or in front of the base of the pectoral fins. Go to 10.

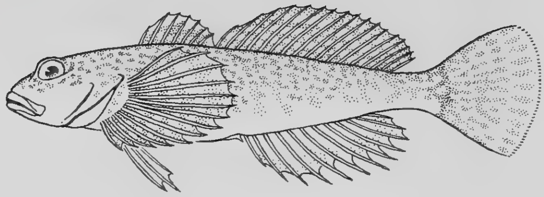


10a. Anal spines two or fewer (spines may be flexible). Go to 11.

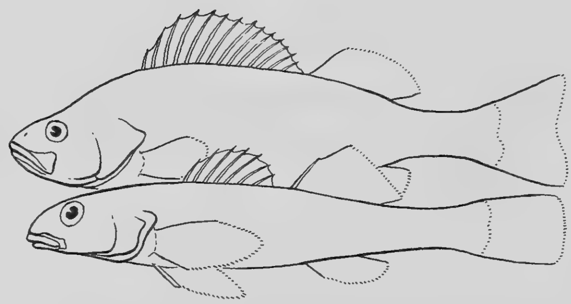
10b. Anal spines three or more. Go to 12.



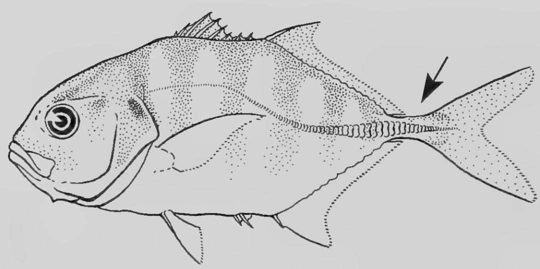
11a. All anal fin elements flexible, no stout fin spines. Sculpin family, Cottidae. One local freshwater species: Slimy Sculpin, *Cottus cognatus,* page 232, Plate 54.



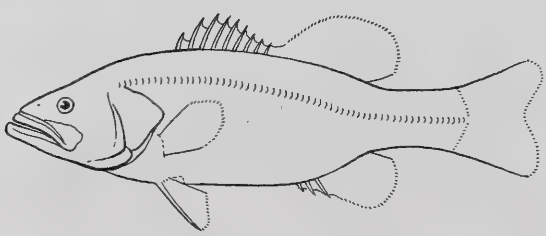
11b. Anal fin with one or two inflexible spines. Perch and darter family, Percidae, page 266.



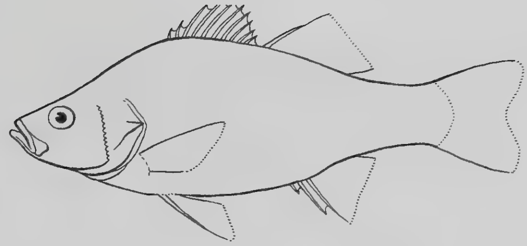
12a. Deeply forked caudal fin with narrow peduncle; bony scutes present on caudal peduncle. Jack family, Carangidae. One local species in freshwater: Crevalle Jack, *Caranx hippos,* page 277.



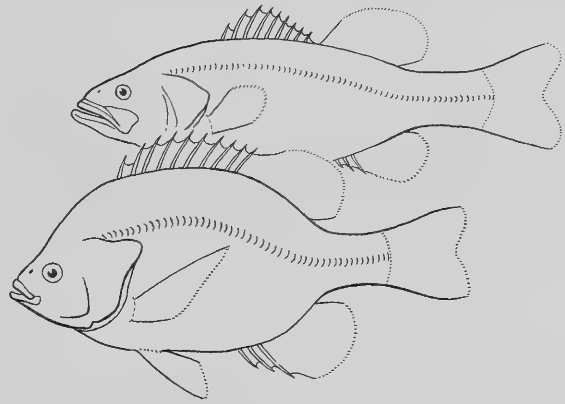
12b. Caudal fin shallowly forked with relatively broad peduncle; no bony scutes on caudal peduncle. Go to 13.



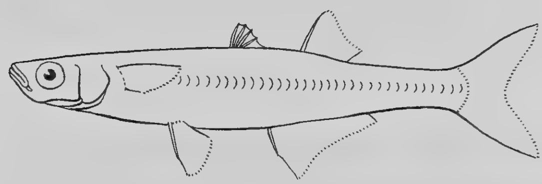
13a. Preoperculum has serrated posterior edge with spine; first and second dorsal fins separated; anal fin squared. Striped Bass family, Moronidae, page 235.



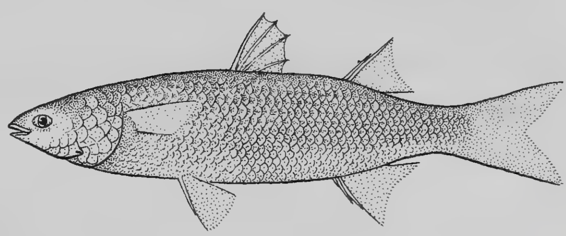
13b. Preoperculum has smooth posterior margin without spine; first and second dorsal fins united, at least by short membrane; anal fins rounded. Sunfish and Black Bass family, Centrarchidae, page 241.



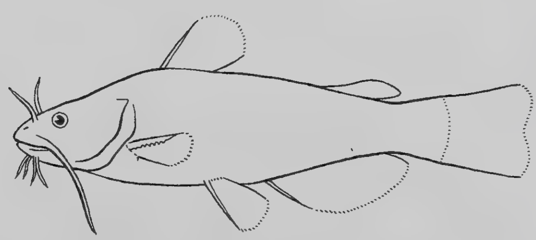
14a. Mouth upturned; origin of second dorsal fin well behind origin of anal fin. Silverside family, Atherinopsidae, page 211.



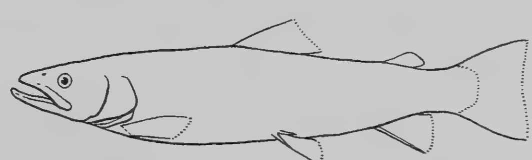
14b. Mouth horizontal; origin of second dorsal fin directly over origin of anal fin. Mullet family, Mugilidae, page 216.



15a. Barbels present; scales absent. Bullhead Catfish family, Ictaluridae, page 143.

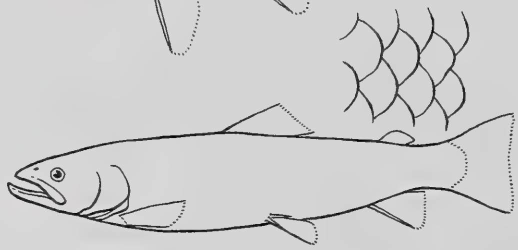


15b. Barbels absent; scales present. Go to 16.

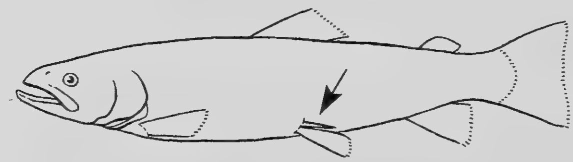


16a. Dorsal fin with two spines; mouth does not extend to front margin of eye; scales with rough posterior edge. Trout-perch family, Percopsidae. One local species: Trout-perch, *Percopsis omiscomaycus*, page 186, Plate 30.

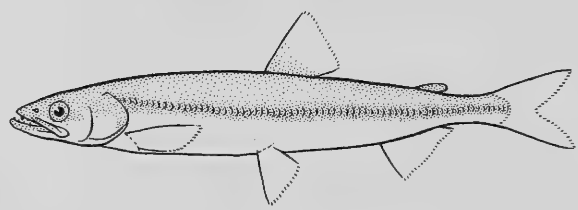
16b. Dorsal fin with no spines; mouth extending beyond front margin of eye; scales with smooth posterior edge (cycloid). Go to 17.



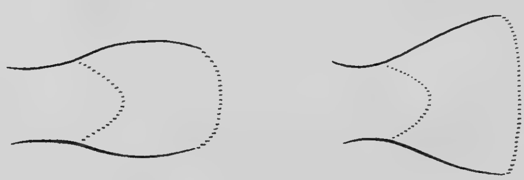
17a. Pelvic axillary process present; more than 100 scales in lateral line series. Trout family, Salmonidae, page 171.



17b. Pelvic axillary process absent; fewer than 80 scales in lateral line series. Smelt family, Osmeridae. One local species: Rainbow Smelt, *Osmerus mordax*, page 168, Plate 43.

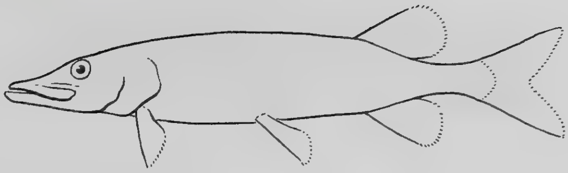


18a. Caudal fin rounded or squared. Go to 25.

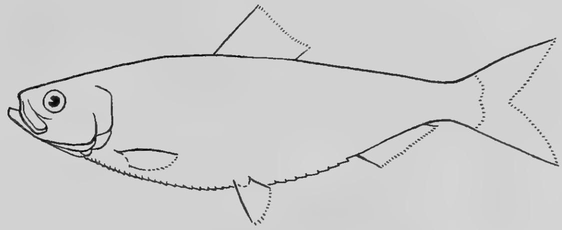


18b. Caudal fin at least partially forked. Go to 19.

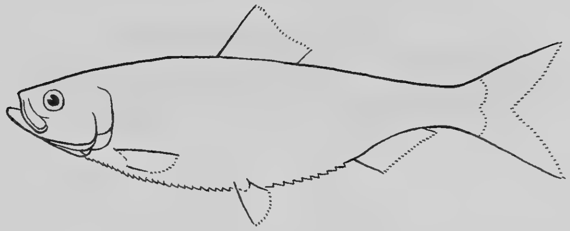
19a. Origin of dorsal fin almost directly above origin of anal fin. Go to 24.



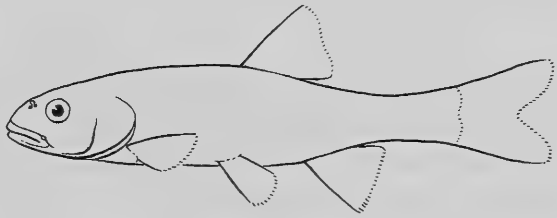
19b. Origin of dorsal fin distinctly in front of origin of anal fin. Go to 20.



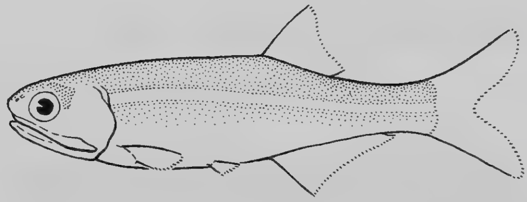
20a. Scales along midline of belly forming a sharp edge or "keel." Herring family, Clupeidae, page 78.



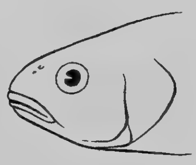
20b. Midline of belly without "keel." Go to 21.



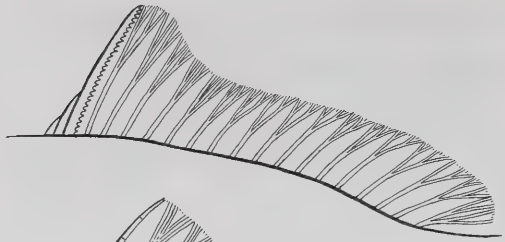
21a. Maxilla extends well past posterior margin of eye. Anchovy family, Engraulidae. One local freshwater species: Bay Anchovy, *Anchoa mitchilli,* page 89.



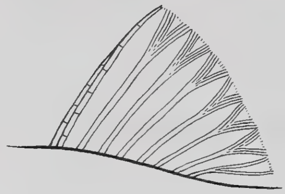
21b. Maxilla does not extend past middle of eye. Go to 22.



22a. Serrated “spine” at anterior edge of dorsal fin. Minnow family (in part), Cyprinidae, page 92.

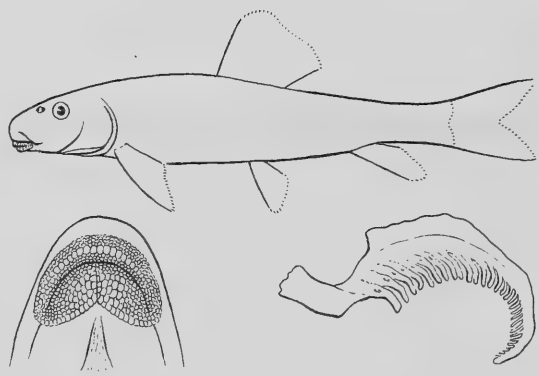


22b. All dorsal fin elements flexible. Go to 23.

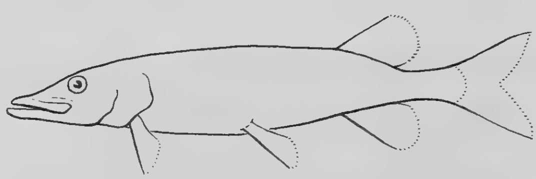


23a. Dorsal fin with nine or fewer rays; lips smooth; pharyngeal teeth in one or two rows with nine or fewer teeth per row. Minnow family (in part), Cyprinidae, page 92.

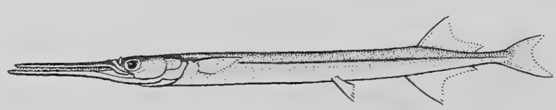
23b. Dorsal fin with 10 or more rays; lips with “pleats”; pharyngeal teeth in one row with over 20 comblike teeth. Sucker family, Catostomidae, page 135.



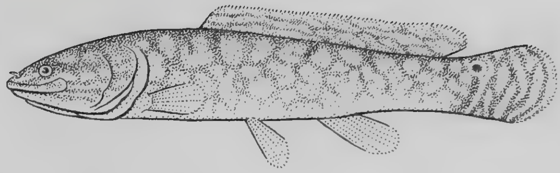
24a. Snout broad and flattened; needle-like beak absent; pectoral fins ventral; dorsal fin rounded. Pickerel family, Esocidae, page 157.

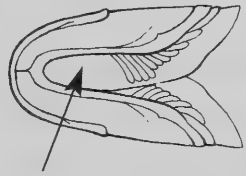


24b. Head narrow and round in cross section; needlelike beak present; pectoral fins lateral; dorsal fin falcate. Needlefish family, Belonidae. One local freshwater species: Atlantic Needlefish, *Strongylura marina,* page 195.

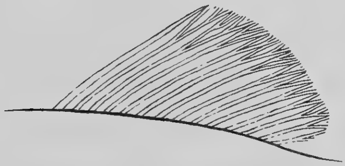


25a. Dorsal fin long (more than 45 rays); gular plate present. Bowfin family, Amiidae. One species: Bowfin, *Amia calva,* page 71.

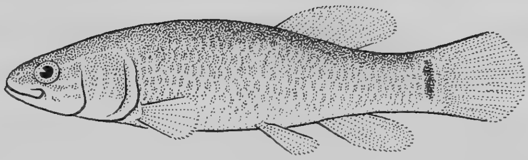




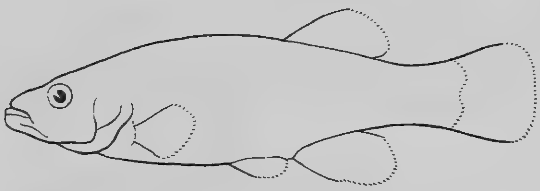
25b. Dorsal fin short (fewer than 15 rays); gular plate absent. Go to 26.



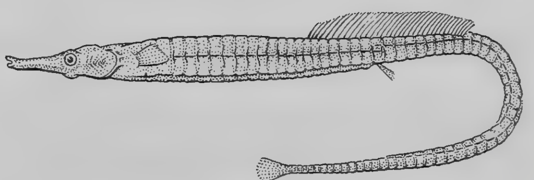
26a. Upper jaw not protrusible; groove between premaxillaries and snout not continuous. Mudminnow family, Umbridae. One local species: Central Mudminnow, *Umbra limi,* page 165, Plate 29.



26b. Upper jaw protrusible; groove between premaxillaries and snout continuous. Killifishlike families, Cyprinodontidae and Fundulidae, page 198.



27a. Body covered with bony rings; mouth modified into tubelike structure; dorsal, caudal, and anal fins distinct. Seahorse and pipefish family, Syngnathidae. One local species: Northern Pipefish, *Syngnathus fuscus,* page 229.



27b. Body not covered with bony rings; mouth not tubelike; dorsal, caudal, and anal fins continuous. Freshwater eel family, Anguillidae. One local species: American Eel, *Anguilla rostrata,* page 75.

Lamprey Family

Petromyzontidae

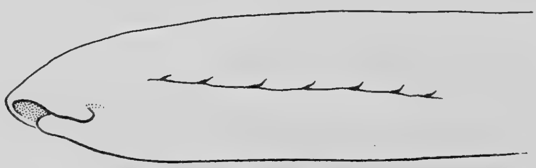
Lampreys and the marine hagfishes are the only surviving jawless fishes. Lampreys have a number of unusual morphological features, including an oral disk that is surrounded by a fleshy hood in the larval stage, horny (keratinized) teeth in the adult, seven pairs of gill openings, and a single nostril (nasohypophseal opening) on the dorsal midline in front of the eyes. In addition, they lack pectoral fins, pelvic fins, scales, true jaws, and ossified skeletons. Lampreys include 41 species in six genera.

The life history of all lampreys is divided into two ecologically and morphologically distinct parts: the larva, often termed an ammocoete, and the adult. The ammocoete lives in freshwater, typically in sheltered backwaters of rivers and streams that have sand and detritus substrates. They are relatively small, blind, filter-feeding burrowers. Depending on the species, adult lampreys are either parasitic and often live for several years, or nonparasitic (actually nonfeeding as adults) and live only a short period after reproducing. Adult lampreys construct shallow, round nests by picking up and arranging stones on the streambottom with their oral sucking disks. Sea Lampreys supported a substantial fishery during Colonial days in New England.

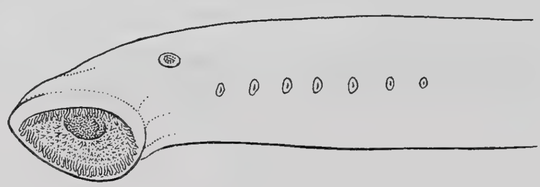
REFERENCES. Hardisty 1979 (biology); Hardisty and Potter 1971–82 (taxonomy, distribution, biology).

Key to Massachusetts Lampreys

1a. Teeth absent, eyes covered with skin, oral hood present. Larval stage, ammocoetes, go to 2.

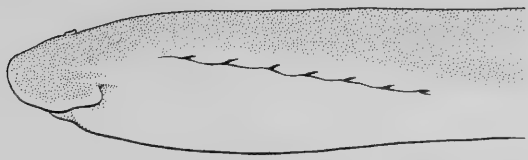


1b. Teeth present, eyes developed, mouth rounded and exposed. Adult stage, go to 3.

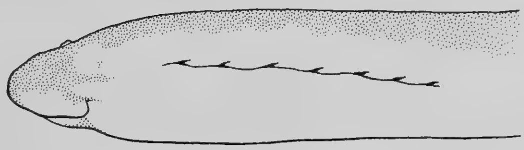


2. Key to Larvae

2a. Unpigmented postnostril area approximately equal to the size of nostril; most of lip pigmented; area above 7 gill openings mostly pigmented. Sea Lamprey, *Petromyzon marinus,* page 64.

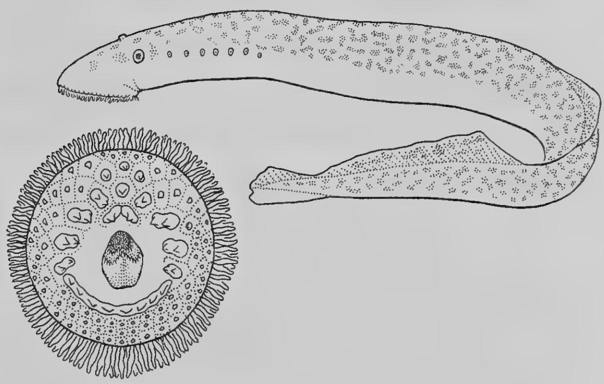


2b. Unpigmented postnostril area about twice the size of nostril; most of lip unpigmented; wide unpigmented band above gill openings. American Brook Lamprey, *Lampetra appendix,* page 62.

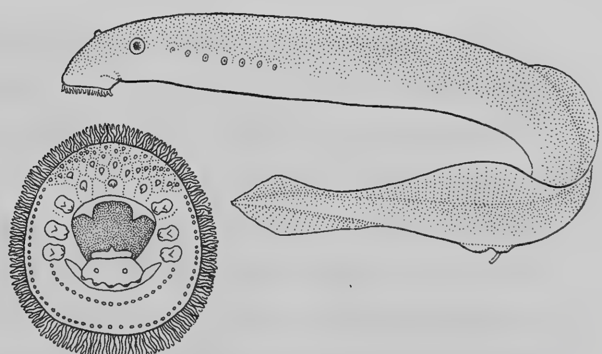


3. Key to Adults

3a. Mouth with many teeth in multiple rows; mature adults generally over 2 feet in length. Sea Lamprey, *Petromyzon marinus,* page 64, Plate 2.



3b. Mouth with scattered horny teeth, multiple rows only in anterior portion (if at all); adults less than 1 foot in total length. American Brook Lamprey, *Lampetra appendix,* page 62, Plate 1.

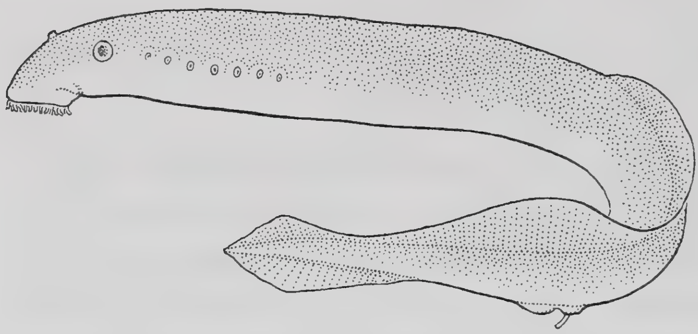


American Brook Lamprey

Native, State Threatened

Lampetra appendix (DeKay 1842)

PLATE 1

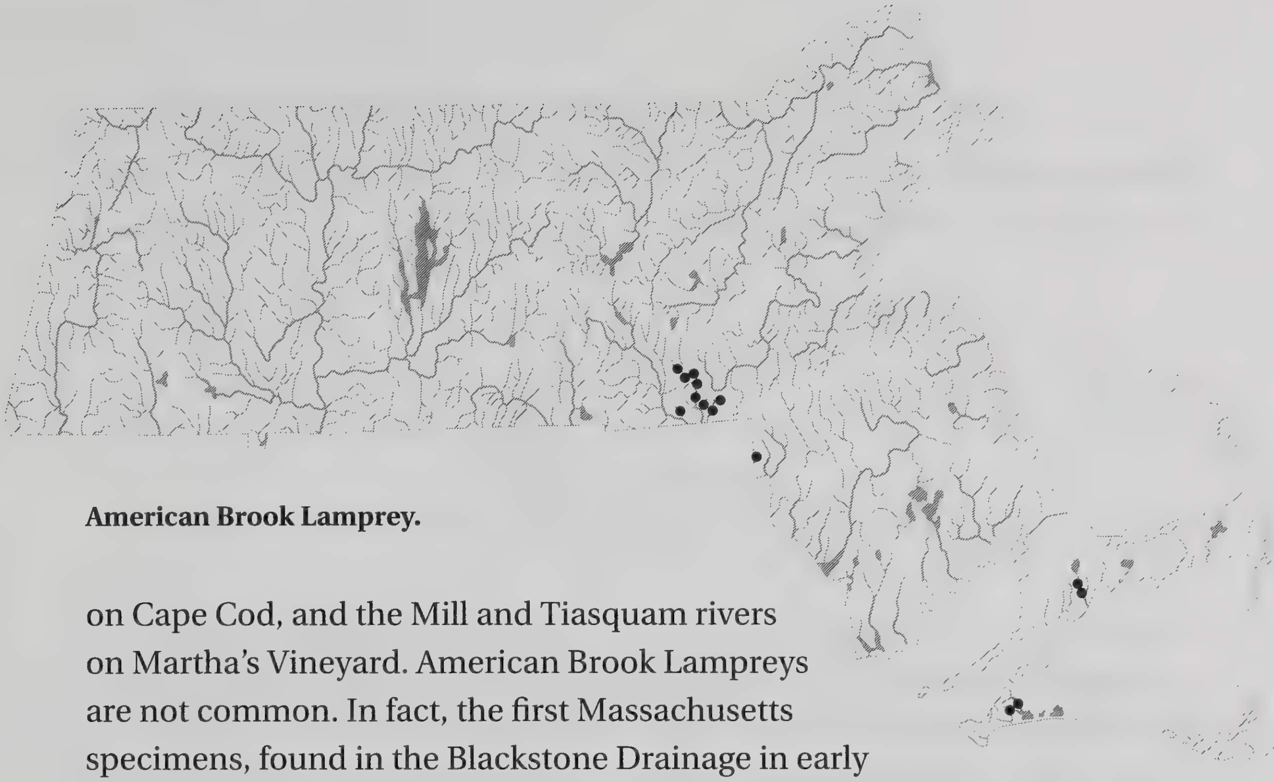


IDENTIFICATION. Lampreys have seven pairs of gills but lack true jaws, pectoral fins, and pelvic fins. Adult American Brook Lampreys seldom grow as large as 8 inches total length (TL), while mature Sea Lampreys are usually over 24 inches TL. Adults of the two species also have distinctive arrangements of the horny teeth in the oral disk (see key Figure 3). The larvae (ammocoetes) can be separated by examining the pigment pattern: American Brook Lampreys lack areas of pigment on the side of the head, on the lips of the oral hood, around the nostril, and along the side of the body above the gill openings (see key Figure 2).

SIZE. Larvae of American Brook Lampreys generally transform to adults at 4 to 6 inches TL. The largest specimen reported from Massachusetts is a transforming individual, 6.75 inches TL.

NATURAL HISTORY. American Brook Lampreys begin to transform into the nonparasitic adult form in the late summer, maturing by late winter or early spring. Soon after completing metamorphosis, the adults construct shallow nests in sandy gravel and spawn from mid-April to early May in Massachusetts. The eggs hatch in nine days at 68°F and, after several days, the young (ammocoetes) burrow into areas of soft substrate. They remain as larvae for four to five years and filter feed mainly on small algae and a variety of other microorganisms found in detritus. Adults do not feed and die shortly after spawning.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, this species is known only from the eastern Blackstone River Drainage, the Mashpee River



American Brook Lamprey.

on Cape Cod, and the Mill and Tiasquam rivers on Martha's Vineyard. American Brook Lampreys are not common. In fact, the first Massachusetts specimens, found in the Blackstone Drainage in early 1950, were misidentified as Sea Lampreys. Finally, in the mid-1960s, a specimen was collected and correctly identified by J. Musick (Virginia Institute of Marine Science) and J. Hoff (South Eastern Massachusetts University) while they were trout fishing in the Mashpee River. The Martha's Vineyard population, which appears stable, went unnoticed until our surveys in 1988.

NOTES. The American Brook Lamprey is listed as a threatened species in Massachusetts because of its limited distribution and the species' sensitivity to environmental change. This species requires streams with clean, silt-free water, riffle areas for nesting, and backwaters with detritus beds for larval growth.

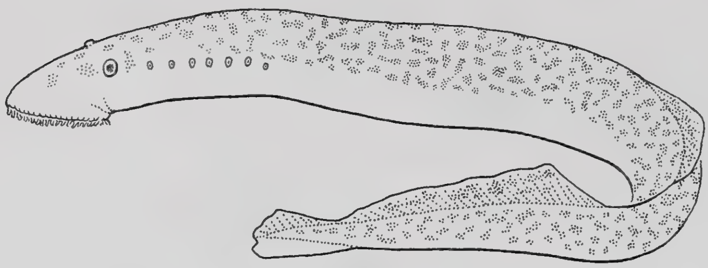
REFERENCES. Halliwell 1979 (Massachusetts); Hoff 1988 (Mashpee River); Moore and Beamish 1973 (habits); Rohde et al. 1976 (life history, Delaware); Vladykov and Follet 1967; Vladykov and Kott 1980 (descriptions, key); Vladykov 1973 (conservation).

Sea Lamprey

Native

Petromyzon marinus Linnaeus 1758

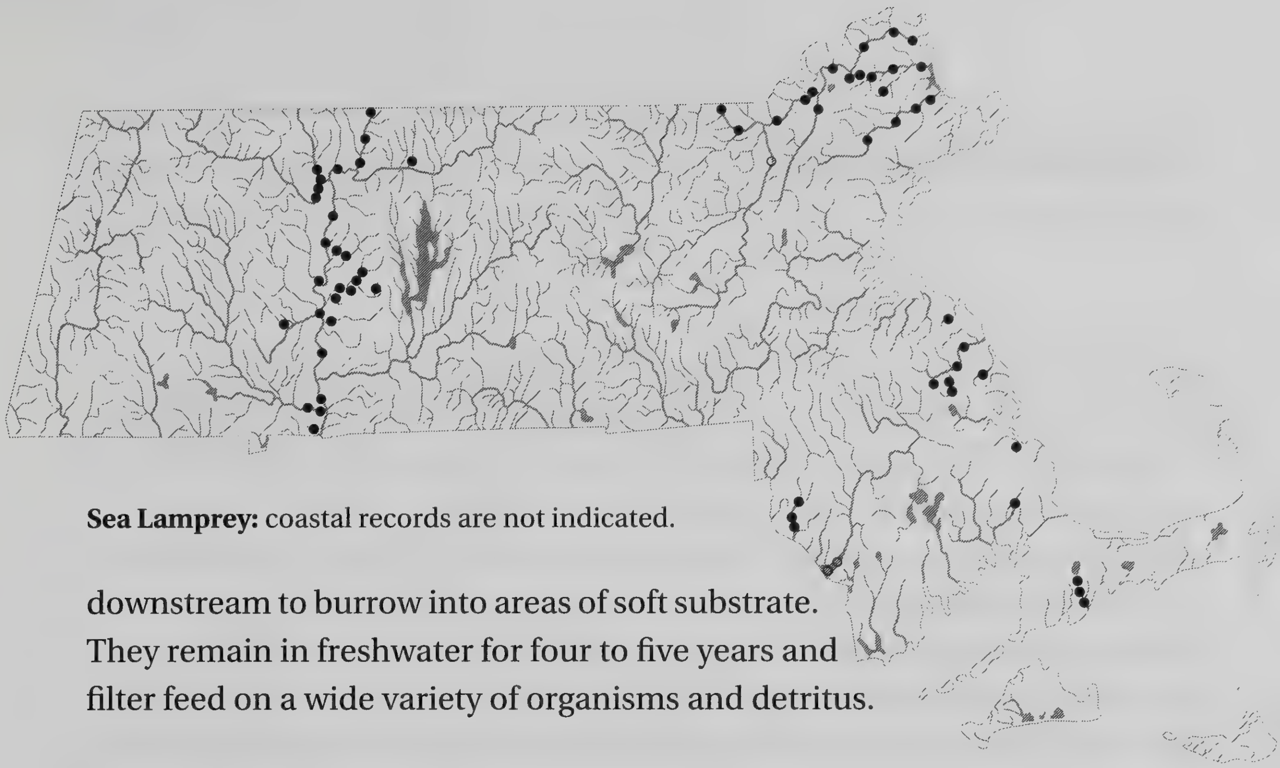
PLATE 2



IDENTIFICATION. Lampreys have seven pairs of gills but lack true jaws, pectoral fins, and pelvic fins. Sea Lampreys are similar to but much larger than American Brook Lampreys; Sea Lampreys are usually over 24 inches TL as adults. Adults of the two species also have distinctive arrangements of the horny teeth in the oral disk (see key Figure 3). The larvae (ammocoetes) can be separated by examining the pigment pattern; Sea Lampreys have much more pigment on the side of the head, on the lips of the oral hood, around the nostril, and along the side of the body above the gill openings (see key Figure 2). Male Sea Lampreys, in breeding condition, develop a prominent ridge along the dorsal midline and a cloacal appendage. These features are absent in the females.

SIZE. Ammocoetes of Sea Lampreys begin to transform into juveniles at 4 to 8 inches TL. Adults, returning from the sea, are from 24 to 34 inches TL at the Holyoke Dam on the Connecticut River.

NATURAL HISTORY. Adult Sea Lampreys return to freshwater after spending at least two years feeding at sea. While in the ocean, they are parasitic and attach themselves to a variety of fishes with their oral disk and feed almost exclusively on the body fluids of the host. Sea Lampreys migrate upriver to small- and medium-sized streams with gravel and rocky substrates in late May or early June as water temperatures reach 50° to 59°F. They remain near the breeding sites for several weeks before spawning but do not feed. Sea Lampreys construct shallow nests by picking up small stones with their oral disks. During spawning, the female attaches to a rock on the upstream edge of the nest and releases between 124,000 and 305,000 eggs over several days. The adult Sea Lampreys die shortly after spawning. The eggs hatch in approximately two weeks, when the young ammocoetes drift



Sea Lamprey: coastal records are not indicated.

downstream to burrow into areas of soft substrate. They remain in freshwater for four to five years and filter feed on a wide variety of organisms and detritus.

DISTRIBUTION AND ABUNDANCE. Prior to the 1800s, Sea Lampreys entered virtually every Massachusetts stream and river that allowed them access to breeding sites. In the mid-1800s, newly constructed dams blocked their migration routes and industrial pollution altered their habitat. Recently, new fishways constructed for anadromous fish runs have allowed them to return to many areas. Sea Lampreys are now common in the Connecticut River (up to 53,000 per year at the Holyoke Fish Lift) and migrate north of the Massachusetts border. The first recent records from the Millers Drainage date from the late 1980s, just after the opening of the Turners Falls Fishway. Sea Lampreys are also locally common in portions of the Merrimack and Parker rivers. They are much less frequently encountered in the South Shore, Cape Cod, and other coastal drainages.

NOTES. Although Sea Lampreys have caused significant damage to the fisheries in several large lakes (notably the Great Lakes), they have no negative effect on the inland fisheries of Massachusetts. The adults and juveniles generally do not feed while in freshwater. However, if Sea Lampreys were to invade any of Massachusetts' larger reservoirs, such as Quabbin, the effects might easily mirror the negative impacts that have occurred in the Great Lakes. Ammocoetes are an important part of stream food webs because they feed on detritus.

REFERENCES. Beamish 1980 (biology); Bigelow and Schroeder 1948, Miller 1980 (distribution, natural history); Stier and Kynard 1986a (abundance, size, sex ratio, MA), 1986b (spawning, MA).

Sturgeon Family

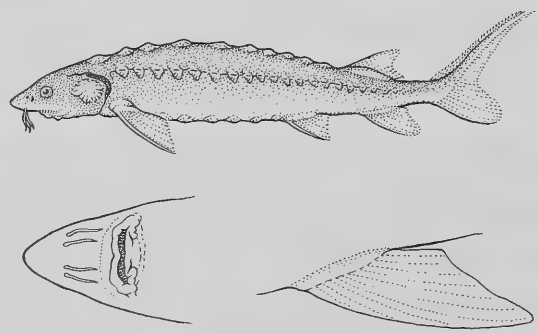
Acipenseridae

Sturgeons are part of an ancient group of fishes that is at least 200 million years old and is closely related to the curious-looking paddlefishes of the Mississippi Drainage and China. Sturgeons are characterized by five rows of bony shields or scutes along the body, a cartilaginous internal skeleton, an intestine with a spiral valve, a heterocercal tail, and a ventral protrusile mouth preceded by four barbels. These fishes are typically anadromous, although some of the world's 25 species live their entire lives in freshwater. Sturgeons are generally sluggish but strong fishes that can leap 4 to 6 feet out of the water. Unfortunately, many sturgeon species are declining. All of the North American species are listed as endangered, threatened, or of special concern in various parts of their ranges.

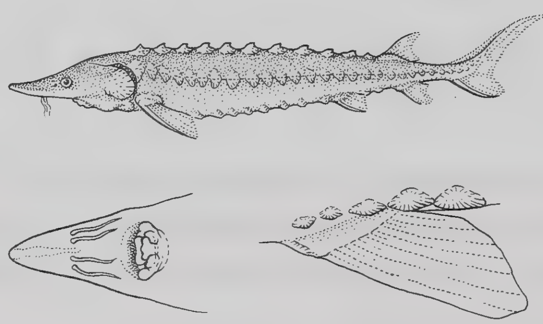
REFERENCES. Binkowski and Doroshov 1985 (biology and management); Lauder and Liem 1983 (relationships); Vladykov and Greeley 1963 (review); Deacon et al. 1979, Ono et al. 1983 (threatened species); Kologe 1992 (MA); Birstein et al. 1997 (biology, relationships, conservation).

Key to Massachusetts Sturgeons

1a. No bony plates between base of anal fin and lateral row of scutes; mouth over 60 percent of interorbital width; intestine and peritoneum dark. Shortnose Sturgeon, *Acipenser brevirostrum*, page 67, Plate 3.



1b. A row of 2 to 6 small bony plates between base of anal fin and lateral row of scutes; mouth less than 50 percent interorbital width; intestine and peritoneum light in color. Atlantic Sturgeon, *Acipenser oxyrinchus*, page 69, Plate 3.

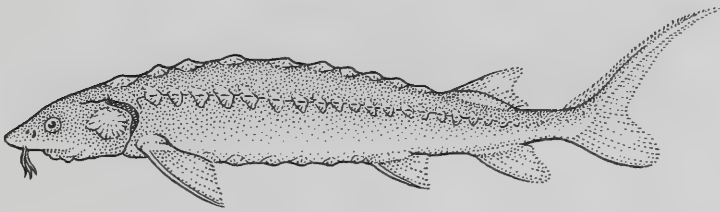


Shortnose Sturgeon

Native, Federally Endangered

Acipenser brevirostrum Lesueur 1818

PLATE 3



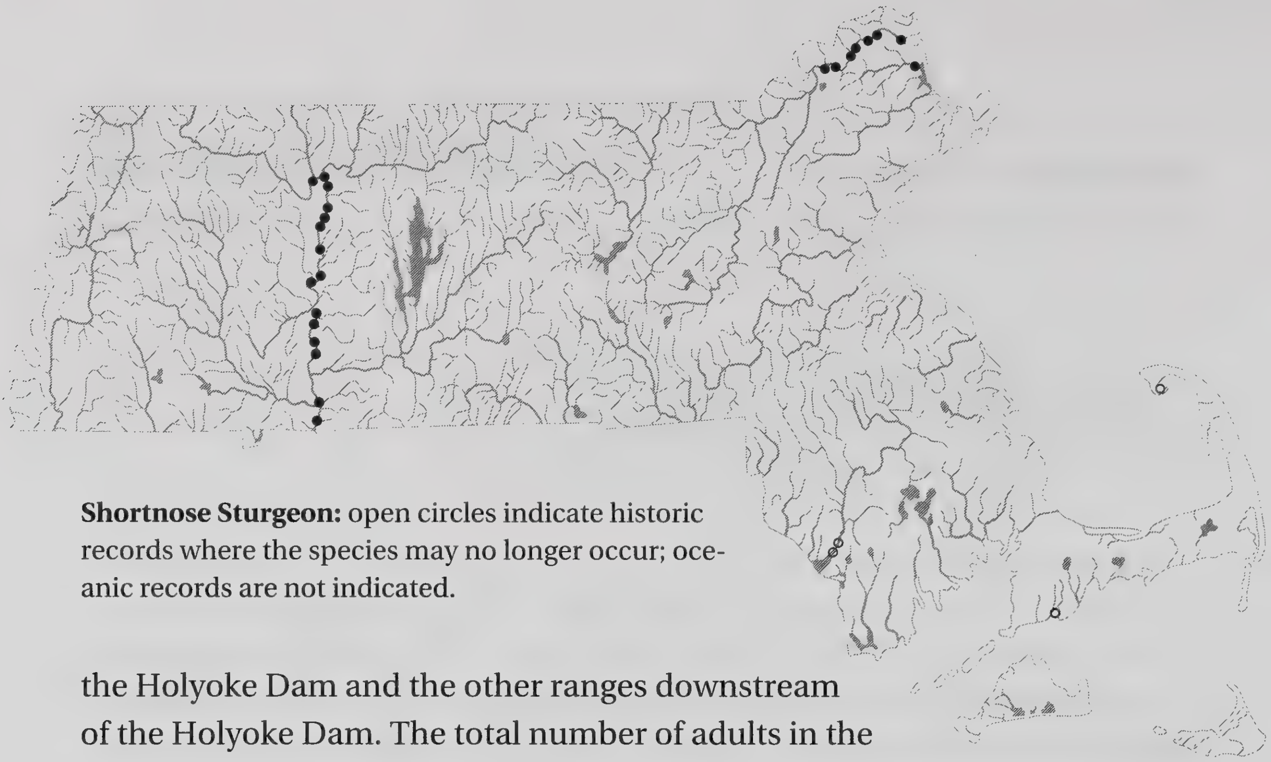
IDENTIFICATION. Shortnose Sturgeon lack small bony plates, or scutes, between the base of the anal fin and the lowest row of primary scutes, and the viscera and lining of the body cavity are blackish. The snout is short and blunt in adults, but its length varies with age and may be relatively long and pointed in juveniles. Young Shortnose and Atlantic sturgeon can be distinguished by the relative width of the mouth (see key Figure 1a). Shortnose Sturgeon never grow larger than 4.5 feet, compared with the 12 to 14 feet attained by Atlantic Sturgeon.

SELECTED COUNTS. D 38–42; A 19–22; GR 13–25.

SIZE. The largest Massachusetts specimens are about 40 inches TL and weigh 20 pounds.

NATURAL HISTORY. Shortnose Sturgeon are often anadromous, but the Massachusetts populations appear to be mostly riverine. In general, Shortnose Sturgeon move upriver in the fall, then overwinter, and spawn in early May. After the spawning season, individuals move downriver, but the movements are complicated because some fishes in each population do not spawn each year. Adults do not spawn until they are almost 10 years old. The oldest documented Massachusetts specimen was 37 years old. Shortnose Sturgeon are bottom feeders with a variable diet; sturgeons of all sizes eat crustaceans and insects, whereas larger individuals eat hard-shelled invertebrates, such as mussels and snails.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, the most stable populations are in the Connecticut River, where two populations exist with little interchange. One is landlocked between the Turners Falls Dam and



Shortnose Sturgeon: open circles indicate historic records where the species may no longer occur; oceanic records are not indicated.

the Holyoke Dam and the other ranges downstream of the Holyoke Dam. The total number of adults in the Connecticut River is thought to be fewer than 1,000 fish. The first confirmed Merrimack record of this species is based on a juvenile specimen collected in 1956 that we found in the Cornell University collection. Shortnose Sturgeon were studied in detail in the lower Merrimack by the Massachusetts Cooperative Fishery Research Unit in 1988. Older records indicate that populations existed in Waquoit Bay, Cape Cod, the Taunton and Parker rivers, and possibly the Charles River.

NOTES. The Shortnose Sturgeon is rare throughout its range and is listed as endangered by the United States Fish and Wildlife Service. Historically, damming, overfishing, and pollution have contributed to the decline of the species.

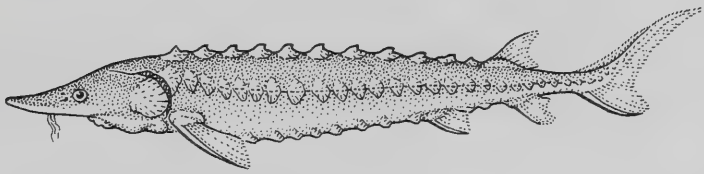
REFERENCES. Buckley and Kynard 1981 (spawning), 1985a (movement), 1985b (habitat and behavior); Dadswell et al. 1984, Kynard 1997 (review); Gorham and McAllister 1974 (identification); Kieffer and Kynard 1993, 1996 (Merrimack); Ono et al. 1983 (threatened species); Tracy 1906 (Taunton River); Taubert 1980 (reproduction).

Atlantic Sturgeon

Native, State Endangered

Acipenser oxyrinchus Mitchill 1814

PLATE 3



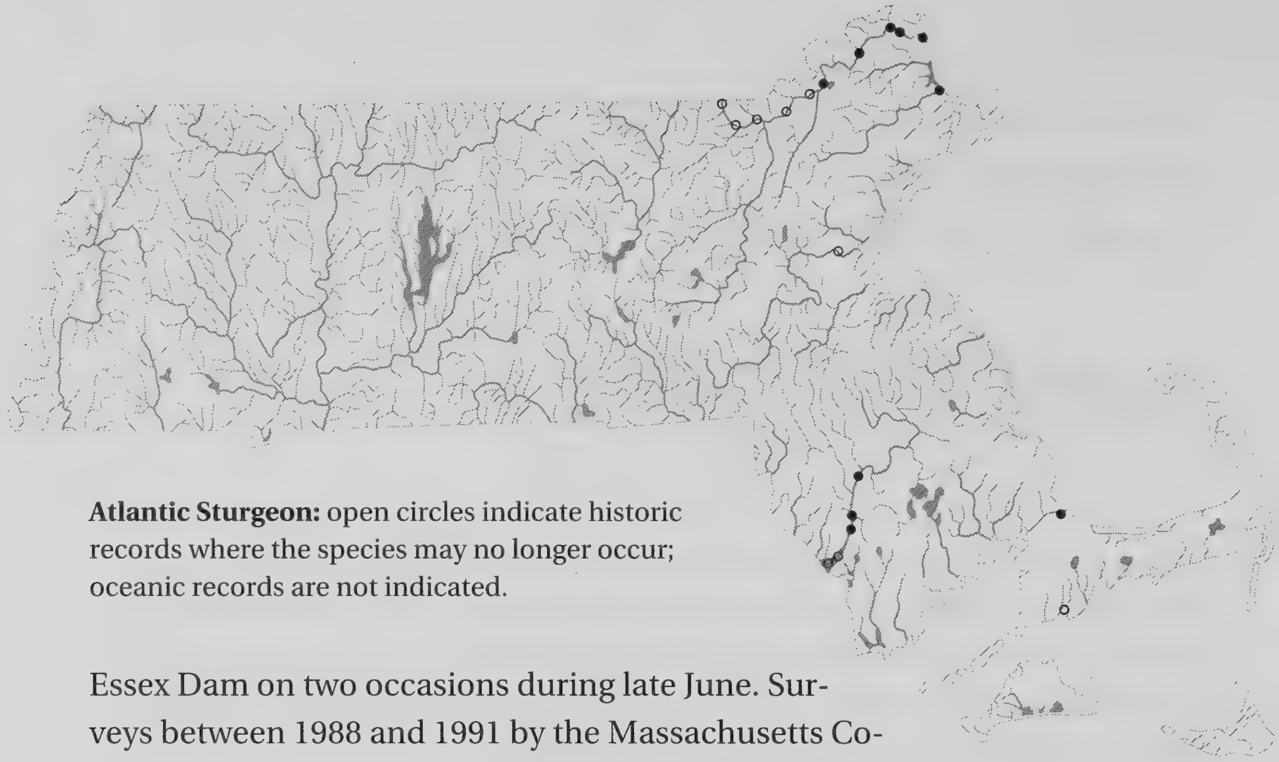
IDENTIFICATION. Atlantic Sturgeon are distinguished from Shortnose Sturgeon by a row of small scutes above the anal fin and by their light-colored viscera. The two species can also be separated by the relative width of the mouth (see key Figure 1b). The snout tends to be long, narrow, and slightly upturned, but its length varies with age.

SELECTED COUNTS. D 38–46; A 26–28; GR 16–27.

SIZE. This is Massachusetts' largest freshwater fish. Historic records from 1634 mention sturgeon of 12, 14, and 18 feet. The 18-foot record is probably an exaggeration, but sturgeons might have grown that large in the past. Typically, Atlantic Sturgeon reach 6 to 9 feet.

NATURAL HISTORY. Historically abundant, this species declined before the turn of the century and almost nothing is known about its natural history in Massachusetts. In other areas, Atlantic Sturgeon are anadromous, with adults moving upriver to spawn over clay, rubble, gravel, or shell bottoms in brackish to freshwater in mid-May to mid-June. The smallest spawning females are close to 20 years old, 6.5 feet long, and 110 pounds. The juveniles usually remain in freshwater for three to four years, or until they reach about 30 inches TL. Older juveniles and adults leave the estuaries in the fall and migrate south along the coast. Young Atlantic Sturgeon feed principally on soft benthic invertebrates, whereas the adults feed on larger invertebrates, such as mollusks. In saltwater, they will eat crabs, worms, and large numbers of Sand Lance *Ammodytes.*

DISTRIBUTION AND ABUNDANCE. In Massachusetts, the species is rare, and recent records are limited to the Merrimack and Taunton rivers. In the mid- to late 1970s, a single, 8-foot-long sturgeon was seen at the base of the



Atlantic Sturgeon: open circles indicate historic records where the species may no longer occur; oceanic records are not indicated.

Essex Dam on two occasions during late June. Surveys between 1988 and 1991 by the Massachusetts Cooperative Fisheries Unit have studied and radio-tagged several 30-inch fish in the vicinity of Haverhill. Whether these fish are part of a reproducing Merrimack population or are just transients is unknown. Historic records indicate that they reproduced in the Taunton River; three juveniles were found there by the Massachusetts Cooperative Fisheries Research Unit in 1991. Specimens are still found in small numbers along the coast and are occasionally taken by trawlers. There are also old records that indicate that this species entered the Charles, the Parker, and other coastal rivers.

NOTES. Historically, this species migrated up the Merrimack River as far as Amoskeag Falls in Manchester, New Hampshire, but the dams erected in the mid-1800s prevented this annual movement. Probably the last large catch of Atlantic Sturgeon was in 1887, when two tons were taken on the Merrimack River in one week.

REFERENCES. Bigelow and Schroeder 1953 (marine records); Murawski and Pacheco 1977, Hoff 1980 (synopsis); Jerome et al. 1965 (Merrimack population); Tracy 1906, Buerkett and Kynard 1993 (Taunton River); Kieffer and Kynard 1993 (Merrimack River).

Bowfin Family

Amiidae

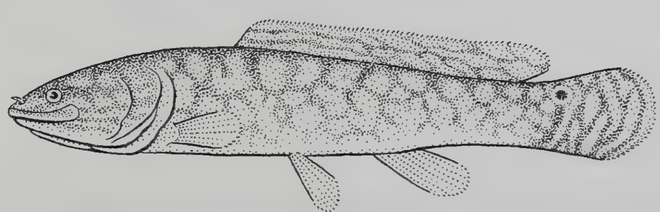
The Amiidae is an ancient family of ray-finned bony fishes that was much more diverse 140 to 200 million years ago. Although they have an extensive fossil record, there is only one living species, the Bowfin of North America. They have a long dorsal fin, a gular plate between the lower jaws, heterocercal tail, and small tubelike anterior nostrils. In addition, Bowfins possess a lung-like gas bladder that enables them to breathe air and occupy habitats that lack the dissolved oxygen required by most other fishes. They also have numerous stout teeth on their jaws and gill arches. As "living fossils," Bowfins are popular in sciences classes, both as an animal for experiments and for anatomical dissections. Bowfins have been of great importance in the analysis of the evolution of vertebrates and the subject of numerous anatomical and behavioral investigations.

REFERENCES. Boreske 1974 (fossil history); Lauder and Liem 1983; Grande and Bemis 1998 (relationships).

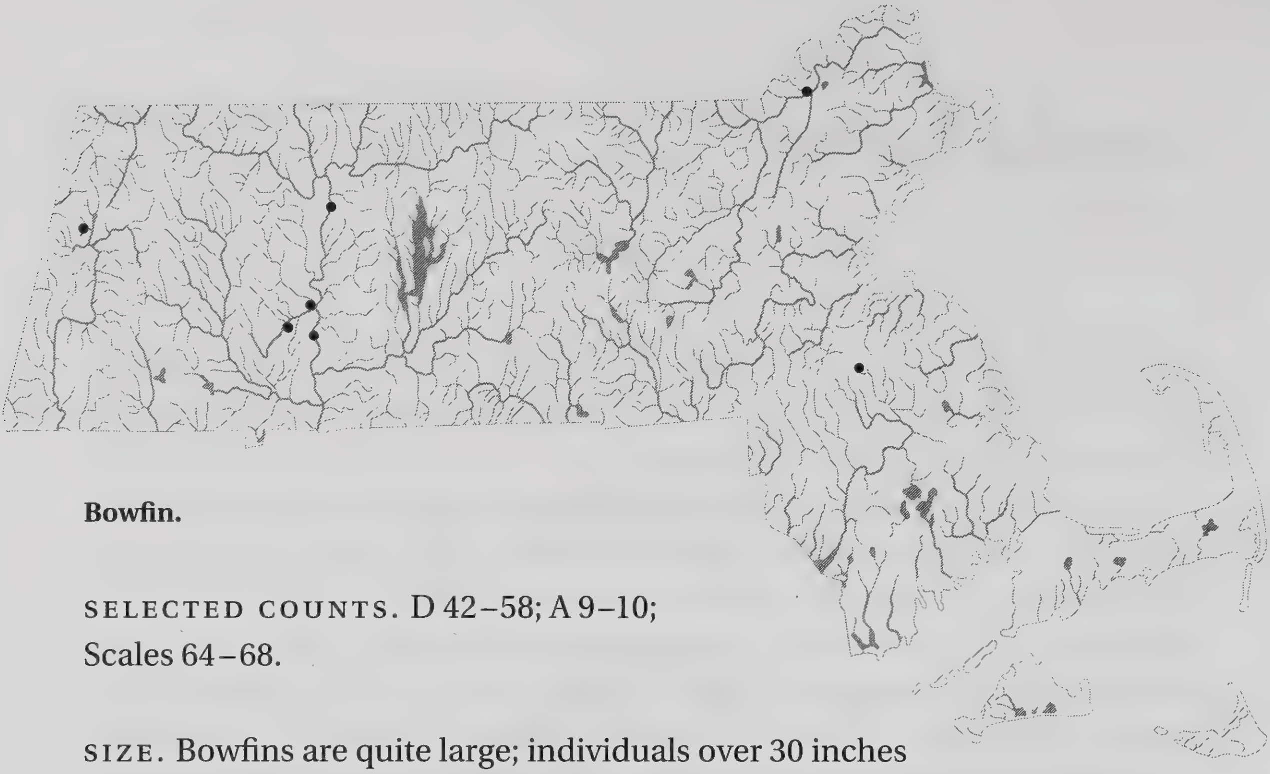
Bowfin

Introduced

Amia calva Linnaeus 1766



IDENTIFICATION. The Bowfin is easily recognized by its long body, long dorsal fin with more than 45 rays, and gular plate. Small Bowfins might be confused with Central Mudminnows since they superficially resemble each other, but the latter lacks a gular plate and has a much shorter dorsal fin. A dark spot on the upper base of the tail is prominent in juvenile and male Bowfins.



Bowfin.

SELECTED COUNTS. D 42–58; A 9–10; Scales 64–68.

SIZE. Bowfins are quite large; individuals over 30 inches long are common in some parts of their range.

NATURAL HISTORY. Bowfins are typically found in vegetated backwaters of rivers but are also found in cool, clear bodies of water. Bowfins are often nocturnal or crepuscular. The males clean a nest area 1.5 to 3 feet in diameter in water less than 3 feet deep and spawn in the spring. Nests are sometimes quite close, and males vigorously defend the nest area and its eggs or young. Newly hatched young adhere to the surrounding vegetation with an adhesive organ on the top of their heads. After young Bowfins leave the nest, they form schools that are continuously protected by adult males for several weeks. Bowfins are voracious feeders; fishes are their primary food source, but they will eat almost any animal they encounter, including crayfishes and frogs.

DISTRIBUTION AND ABUNDANCE. Endemic to North America, this species is found west and south of the Hudson River. The source of the introduction to Massachusetts waters is unknown. Prior to the late 1980s, the only record from Massachusetts was of a single Bowfin specimen taken from Lake Onota in Pittsfield, during 1974. In 1986, however, a number of specimens were found in an impoundment in Easthampton, and the following year a large specimen was taken from the Connecticut River in Sunderland. A specimen was also reported from the fishlift at Lawrence on the Merrimack River in 1986. An adult male and female were identified by R. Hartley (MDFW) from Lake Waldo, Brockton, in 1996. In 1992, a 4-inch ju-

venile was dropped by a Belted Kingfisher along the Connecticut River in Hadley in 1992, which confirmed reproduction in the wild.

NOTES. Bowfins are just one of many types of fishes that have evolved various methods of breathing air. Bowfins use their lung-like gas bladder, as do lungfishes. Other groups of fishes respire using modifications of their buccal cavity, and some swallow air to extract the oxygen in the intestines.

REFERENCES. Lagler and Hubbs 1940 (diet); Lauder 1980 (feeding); MacKay 1963 (reproduction); Reighard 1900 (natural history), 1902 (reproduction).

Freshwater Eel Family

Anguillidae

Eels belong to the order Anguilliformes, which contains some 25 families and more than 600 species. Eels are elongate, snakelike fishes without pelvic fins or fin spines. The tarpons and bonefishes do not look like eels but are members of this same order. Both true eels and tarponlike fishes have a specialized larva called a "leptocephalus" that links the two groups. The freshwater eels, Anguillidae, are probably the most familiar and commercially important. They are one of the most generalized eel groups and have small imbedded scales that are lacking in almost all other eels. Freshwater eels are catadromous; that is, the eggs hatch in the sea, the young migrate to freshwater to grow, and the adults return to the sea to spawn. Both the American and European eels breed southwest of Bermuda; then the larvae make their way back to the coasts of America and Europe. The adults have never been captured or seen in the breeding area, and the exact depth and method of spawning remains a biological mystery.

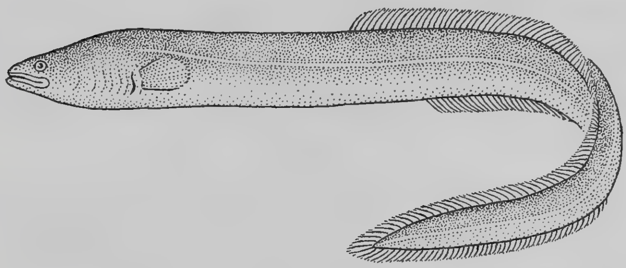
Freshwater eels are considered a delicacy in Europe and Japan. They are commercially important in Europe, where about 15,000 metric tons are harvested each year. These eels are not used as much in North America; the annual harvest in the United States is only 2,000 metric tons, most of which is exported to Europe.

REFERENCES. Schmidt 1922 (discovery of the breeding area); Tesch 1977 (general); Ege 1939, Smith 1989 (review and description).

American Eel

Native

Anguilla rostrata (Lesueur 1817)

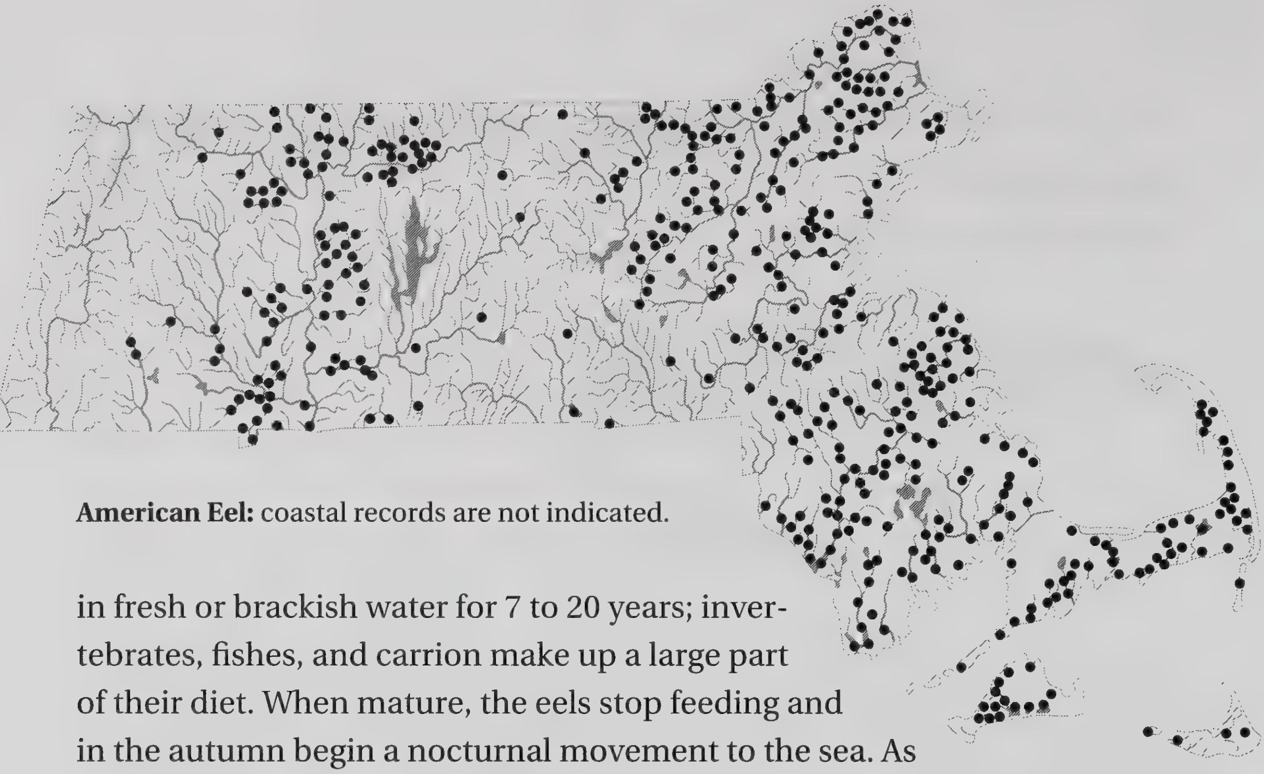


IDENTIFICATION. Eels can be identified by their elongate, snakelike bodies, single small gill openings, true jaws, and pectoral fins. The dorsal fin begins far behind the pectorals in American Eels, which distinguishes them from the Conger Eel, *Conger oceanicus,* which is found in Massachusetts marine waters. Color varies in eels: at sea, larval eels are nearly transparent and colorless and, as they first assume adult shape, retain their transparency and are called "glass eels." Upon reaching freshwater, the larvae gradually develop pigment to become bronze-black above and silver-white below as adults.

SELECTED COUNTS. D 240; A 200; Vert 103–111.

SIZE. Female American Eels may grow to over 4 feet TL and weigh up to 16.5 pounds. A 52-inch female, weighing 7 pounds 8 ounces, and with a girth of 7.5 inches, was taken on hook and line from Santuit Pond, Mashpee. Males are much smaller than females, usually 12 to 14 inches TL. Any American Eel over 16 inches TL is undoubtedly a female.

NATURAL HISTORY. American Eels that live in Massachusetts are spawned in the open ocean south of Bermuda. After hatching, the larval eels begin a yearlong journey to New England; presumably, they are carried northward on the ocean currents. Off the continental shelf, they begin transformation into a 2- to 2.5-inch, transparent, adultlike glass eel. Beginning in March, glass eels enter the estuaries and assume adult coloration. Many of these juveniles, or elvers, remain in the estuaries, but many thousands migrate hundreds of miles up rivers. Only the largest dams stop them, since they can usually crawl up cracks and crevices in the face of small dams. Eels live



American Eel: coastal records are not indicated.

in fresh or brackish water for 7 to 20 years; invertebrates, fishes, and carrion make up a large part of their diet. When mature, the eels stop feeding and in the autumn begin a nocturnal movement to the sea. As they migrate, many body changes take place; most noticeably, they become bronze-black above and silver-white below and the males' eyes almost triple in size.

Reproductively mature eels have never been seen in the wild, but laboratory studies show that even more body changes take place. Teeth are lost, the pectoral fin becomes longer, the gas-producing properties of the swimbladder and associated capillaries change, and even the retinal pigments adapt to the low blue light of the ocean. The fully ripe females are almost nothing more than a bag of eggs. A large female may contain up to several million eggs in a belly so swollen that it appears that the eel can hardly function. Almost surely, eels die shortly after spawning, but adults have never been seen in the spawning area. The eels' tolerance of habitats that range from freshwater streams to open ocean over a mile deep, as well as their odyssey as larvae and again as adults, make this drab-looking fish truly remarkable.

DISTRIBUTION AND ABUNDANCE. American Eels are common along the Massachusetts coast as well as in ponds, rivers, and streams that are connected to the ocean. Eels travel overland at night in wet weather and can move long distances underground in pipes and culverts, which is why they are found in ponds or lakes that appear to lack connections with the sea. Though American Eels are still common, a rangewide study by Alex Haro (Conti Anadromous Fish Research Center) and colleagues shows declines in populations between 1984 and 1995.

NOTES. Eels were a very valuable commercial Massachusetts fishery. Over 240,000 pounds were taken in 1919; however, by 1947, only 33,000 pounds were taken annually. Catches have varied through the years since then due to economy and demand rather than the actual abundance of eels. In the late 1970s, a large export fishery existed but this market collapsed with the changing dollar and with the discovery of pollutants in eel flesh. Currently, only a small local market for eels as food and bait exists in Massachusetts.

REFERENCES. Bigelow and Schroeder 1953 (life history); Haro and Krueger 1988 (pigmentation, size, migration); Smith 1989 (systematics, life history, physiology). Haro et al. 2000 (population declines).

Herring Family

Clupeidae

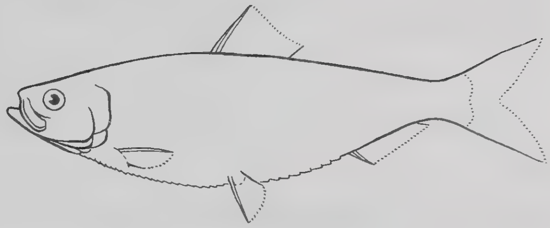
The herring family, closely related to the anchovies, contains about 180 species in 56 genera. The family is united by having a well-developed lateral-line system on the head that extends onto the operculum and a specialized stethoscopelike connection between the gas bladder and the skull. Many herrings have laterally compressed bodies, with thin, loosely attached scales, and are usually silver. Their teeth are small or absent, and their gill rakers are often numerous, long, and thin. While often found in marine environments, many herrings enter rivers to spawn, and some species live completely in freshwater. Herrings have a worldwide distribution and are extremely abundant in many coastal regions. They are primarily planktivores, but some species will eat larger prey, including small fish. Small prey are usually filtered out of the water, but larger prey are individually picked out of the water column. The family includes all of the fishes commonly marketed as sardines. Clupeids are one of the world's most commercially fished groups. In the early 1980s, they accounted for approximately 30 percent of the world's marine fish harvest, with 14 million tons taken each year.

The Hickory Shad, *Alosa mediocris,* is included in the identification key but not in the species accounts because it does not enter freshwater in Massachusetts. Other herrings, including the Atlantic Herring, *Clupea harengus,* and the Atlantic Menhaden, *Brevoortia tyrannus,* are common in Massachusetts coastal waters but seldom stray near the lower edge of freshwater.

REFERENCES. Bigelow and Schroeder 1953 (general, Gulf of Maine); Hildebrand 1963 (Western Atlantic); Whitehead 1985 (review, general biology, and systematics).

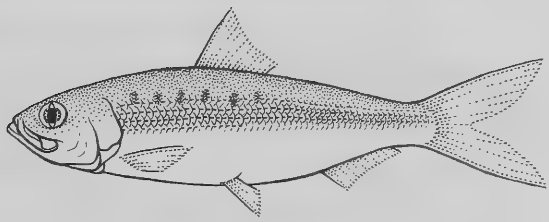
Key to Massachusetts Herrings and Shad

1a. Mouth terminal, last dorsal ray not elongate, adults with fewer than 75 lower gill rakers. Go to 2.

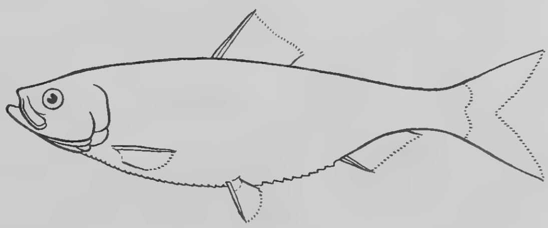


1b. Mouth slightly subterminal, last dorsal ray elongate, adults with more than 100 lower gill rakers. Gizzard Shad, *Dorosoma cepedianum,* page 86, Plate 7.

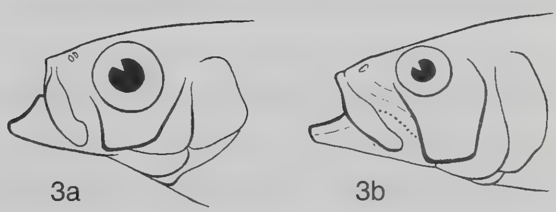
2a. Only 18 to 24 gill rakers on lower limb of first gill arch; lower jaw strongly projecting. Hickory Shad, *Alosa mediocris.* See family account.



2b. More than 35 gill rakers on lower limb of first gill arch; lower jaw not projecting. Go to 3.

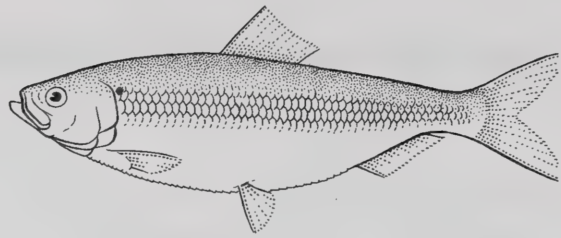


3a. Cheek as wide as deep; outline of upper jaw concave. Go to 4.

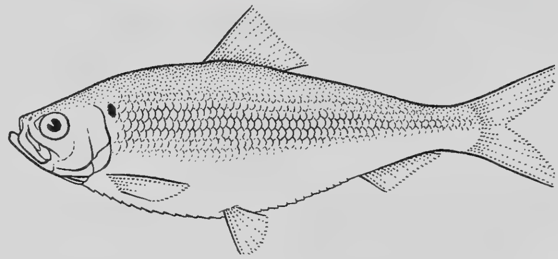


3b. Cheek deeper than wide; outline of upper jaw not concave. American Shad, *Alosa sapidissima,* page 84, Plate 6.

4a. Eye diameter generally less than or equal to length of snout; peritoneum black. Blueback Herring, *Alosa aestivalis*, below, Plates 4, 5.



4b. Eye diameter greater than snout length; peritoneum pale with dusky spots. Alewife, *Alosa pseudoharengus*, page 82, Plate 5.

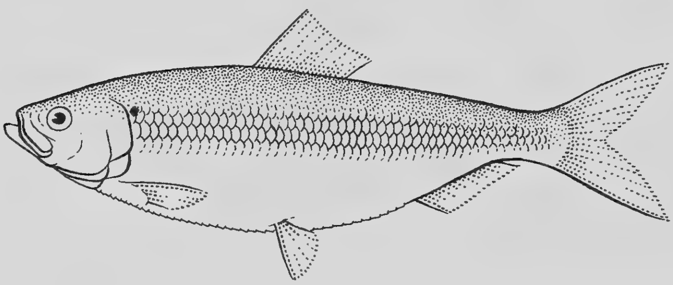


Blueback Herring

Alosa aestivalis (Mitchill 1814)

Native

PLATES 4, 5

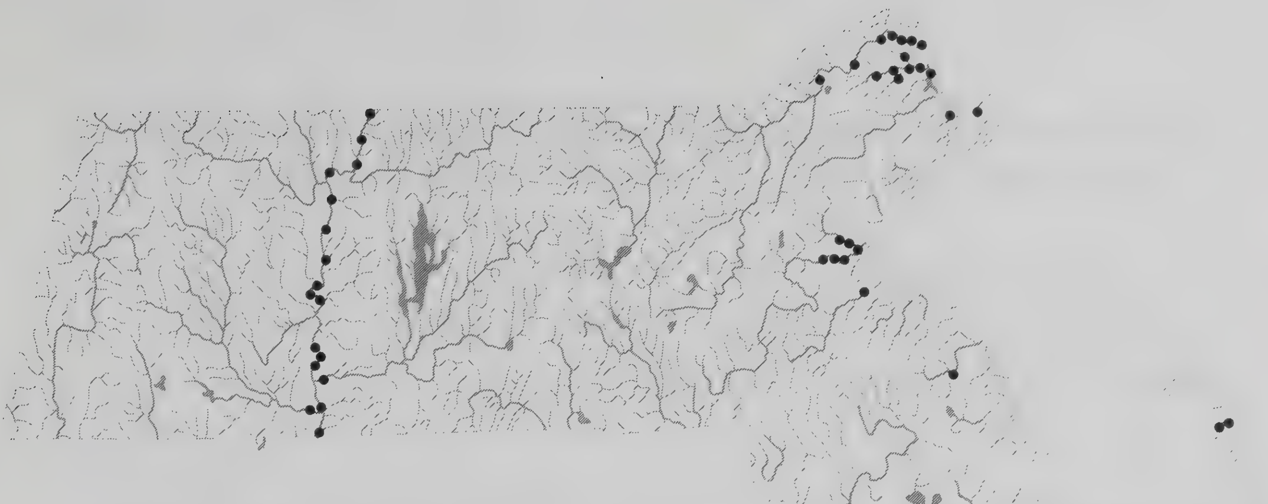


IDENTIFICATION. The Blueback Herring can be distinguished from the larger shad by the shape of the lower jaw and depth of the cheek (see key Figure 3b). It is similar to the Alewife, but the diameter of the Blueback's eye is less than or equal to the length of the snout and the peritoneal lining of the body cavity is dusky-grey to black. The Blueback Herring's back and upper sides tend to be a bluish color.

SELECTED COUNTS. D 15–20; A 16–21; Scales 41–48; GR (lower) 41–52.

SIZE. Adults are usually 10 to 12 inches TL. Young-of-the-year are generally less than 3 inches TL while in freshwater.

NATURAL HISTORY. Blueback Herring are anadromous; they begin their local spawning runs in mid- to late spring when the water temperature



Blueback Herring: coastal records are not indicated.

reaches 57°F. Peak spawning occurs with water temperature of 69° to 75°F. Spawning occurs in swift-flowing sections of streams with gravel or rocky bottoms. The fertilized eggs sink to the bottom and hatch in less than one week. As in other herring species, fecundity is high with each female carrying up to 400,000 eggs. The adults migrate back to salt water after the brief spawning period. The young form large schools and slowly work their way downstream to the sea between September and early November. Downstream migration is triggered when water temperature drops to about 69°F. In freshwater, young Bluebacks eat copepods and some cladocerans. In marine waters, adults feed on a variety of marine invertebrates, including pelagic shrimp. Their first spawning migration occurs at two to four years. Blueback Herring frequently live to eight years.

DISTRIBUTION AND ABUNDANCE. Blueback Herring are common in Massachusetts and enter numerous coastal streams. Since they were often confused with Alewives, little information is available regarding their historical abundance. However, like other river herrings, their populations have been reduced or eliminated in some areas by damming and pollution. Bluebacks are abundant in the Connecticut and Merrimack rivers, where they migrate as far upstream as New Hampshire or Vermont. More than 440,000 are passed most years at the Holyoke Fish Lift on the Connecticut River (see Figure 3).

NOTES. As is true of many other anadromous species, the long migrations undertaken by Blueback Herring are currently possible only because of the improvements to Massachusetts fishways since the mid-1950s. Besides

allowing the fishes simply to pass, the fishways greatly increase the area available to Blueback Herring for spawning and feeding (Figure 3).

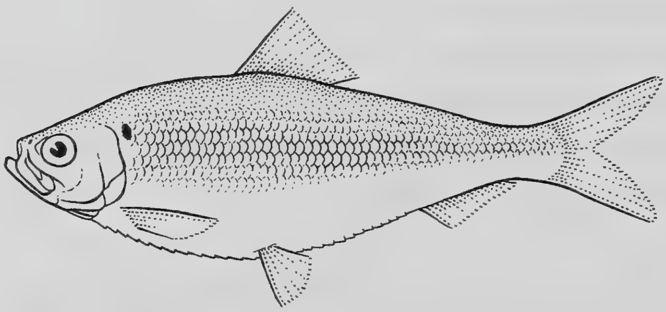
REFERENCES. Bigelow and Schroeder 1953 (general); Clayton et al. 1978 (review); Domermuth 1976 (food); Scherer 1972 (biology, Connecticut River); O'Leary and Kynard 1986 (behavior).

Alewife

Native

Alosa pseudoharengus (Wilson 1811)

PLATE 5

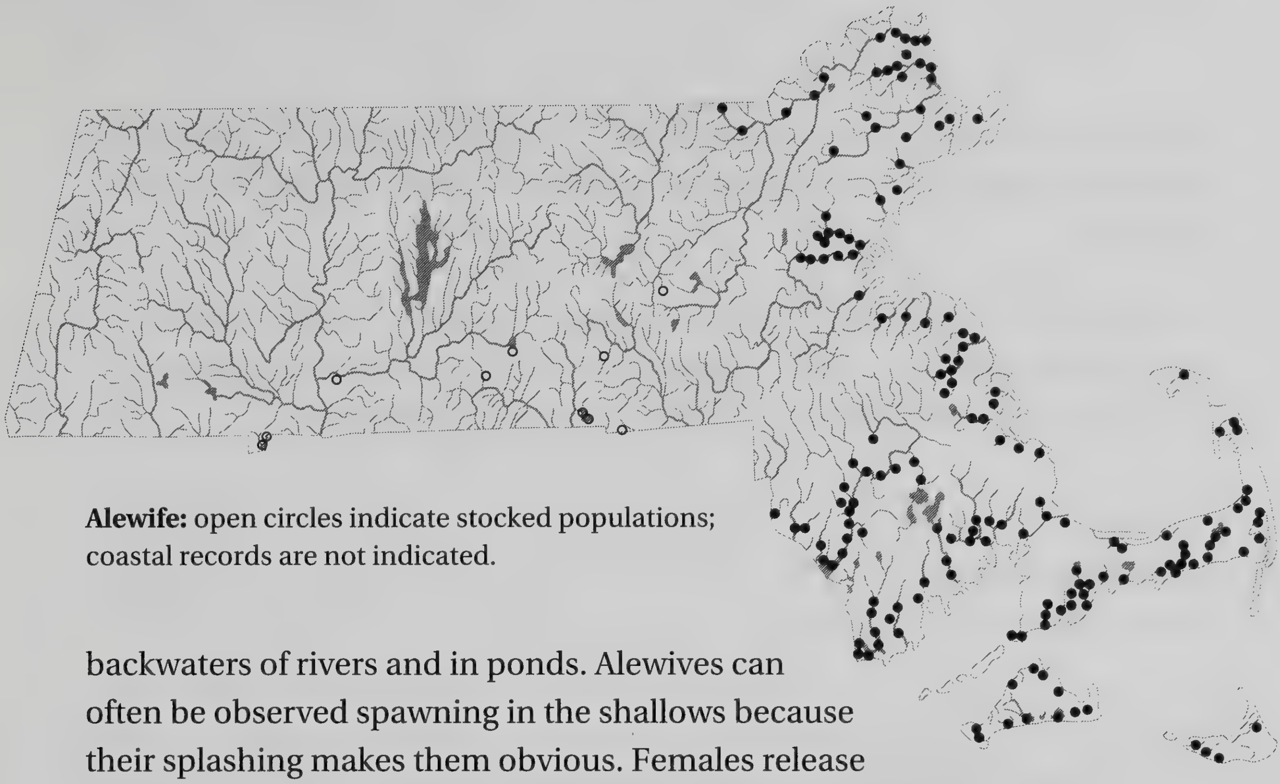


IDENTIFICATION. Alewives can be distinguished from the generally larger shad by the shape of their lower jaw and the depth of the cheek (key Figure 3b). Alewives and Blueback Herring are similar but the diameter of an Alewife's eye is greater than the length of the snout, and Alewives have a pale peritoneum with small spots that is never dusky to black. The back and upper sides tend to be greenish.

SELECTED COUNTS. D 15–19; A 15–18; Scales 42–50; GR (lower) 36–43.

SIZE. Adults are usually 10 to 12 inches TL. Young-of-the-year return to the sea before they are 4 inches TL.

NATURAL HISTORY. Alewives are anadromous; they spend most of their adult life in coastal marine waters and return to freshwaters to spawn. Spawning runs begin in midspring as water temperature reaches 52°F. During these runs, schools of Alewives swim upstream, spawn numerous times over several days, and swim downstream, often passing other schools on their way up to the spawning grounds. Spawning occurs in sluggish



Alewife: open circles indicate stocked populations; coastal records are not indicated.

backwaters of rivers and in ponds. Alewives can often be observed spawning in the shallows because their splashing makes them obvious. Females release 60,000 to 300,000 eggs, which stick to the substrate or vegetation. Although these annual spawning migrations are physiologically stressful, most adults survive and are able to repeat the process in subsequent years. After hatching, juveniles form large schools and slowly work their way downstream to the sea. While in freshwater, the young feed primarily on zooplankton. After reaching marine waters, Alewives feed on zooplankton, small fishes, and crustaceans. They become sexually mature after three years and frequently live to nine years.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Alewives are now found in most coastal rivers. Colonial accounts mention their extreme abundance. Alewives are still common in some areas, but they have been eliminated or reduced in others by damming, pollution, and development. Fishways, in place on many streams for hundreds of years, have maintained or enhanced numerous populations. Alewives are frequently found in the coastal salt ponds on Nantucket and Martha's Vineyard when inlets to these ponds have been opened to the sea. They have also been introduced to a number of inland lakes in Massachusetts, including Congamond, Singletary, and Webster lakes, and South Pond, Brookfield.

NOTES. Alewives are harvested while at sea for a variety of commercial purposes, including consumption by humans and other animals. During the spawning runs, many fish are dipnetted under town permits in Massa-

chusetts. As herrings are often visible and vulnerable during their spawning runs, the fishery is strictly regulated to protect this economically important species.

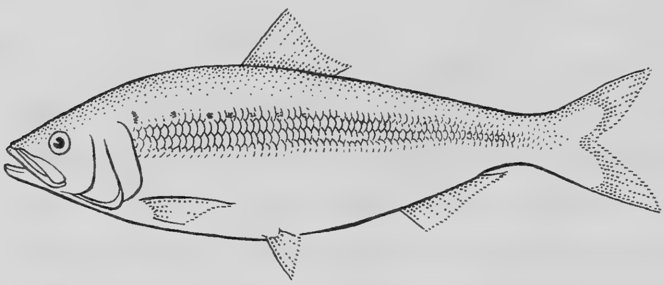
REFERENCES. Bigelow and Schroeder 1953; Grosslein and Azarovitz 1982 (general); Clayton et al. 1978 (biology, MA); Belding 1921, Reback and DiCarlo 1972 (distribution, MA); Palmer 1999 (Neponset River).

American Shad

Native

Alosa sapidissima (Wilson 1811)

PLATE 6

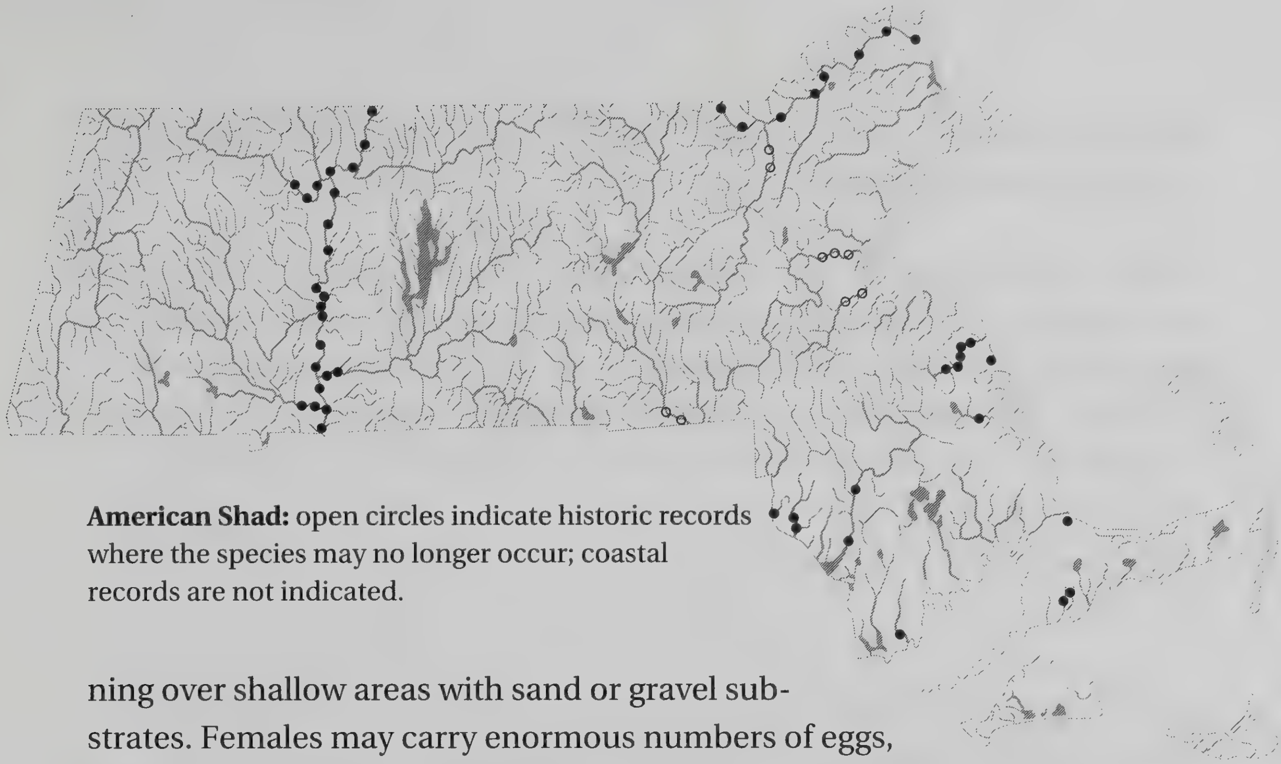


IDENTIFICATION. American Shad have a deeper than wide cheek and a straight upper edge of the lower jaw (see key Figure 3a). As adults, they grow to a larger size than any other Massachusetts herrings and have more gill rakers than all of the other herrings except the Gizzard Shad. Hickory Shad, which are known from Massachusetts marine waters, have a strongly projecting lower jaw and only 18–23 lower gill rakers.

SELECTED COUNTS. D 15–20; A 19–23; Scales 50–55; GR (lower) 59–75.

SIZE. Most adult American Shad range from 1.5 to 2 feet TL, but they can grow larger. The Massachusetts angling record is an 11-pound, 4-ounce fish taken from the Connecticut River in 1986.

NATURAL HISTORY. American Shad are anadromous; they begin their migration from the sea to the freshwater spawning grounds in late spring when river temperatures reach 50° to 55°F. They may move long distances up rivers and migrate into New Hampshire in both the Connecticut and Merrimack rivers. Spawning generally occurs in the late afternoon or eve-



American Shad: open circles indicate historic records where the species may no longer occur; coastal records are not indicated.

ning over shallow areas with sand or gravel substrates. Females may carry enormous numbers of eggs, up to 500,000 in large individuals. After spawning, adult American Shad migrate back to marine environments. The eggs gently sink to the bottom and roll downstream. Eggs hatch in three to eight days. The young form large schools and feed in the river until they grow to about four inches. The downstream, seaward-movement of the young is triggered as water temperatures drop to about 66°F. Migration takes place primarily in the late afternoon and evening from September to early November.

Adult American Shad eat a wide variety of zooplankton, shrimp, and small fishes. In freshwater, the adults eat little and only occasionally feed on small prey. The young-of-the-year feed on small midwater copepods, ostracods, and insects. American Shad first spawn at the age of four or five years, and adults may live to 10 years of age.

DISTRIBUTION AND ABUNDANCE. Historically in Massachusetts, the American Shad entered most coastal streams. Damming, dredging, pollution, and other alterations of Massachusetts waters caused large declines in the mid-1800s, when American Shad were eliminated from the Massachusetts portions of the Connecticut, Blackstone, and Charles rivers. The Merrimack suffered declines because fishes were not able to move above Lawrence and Lowell. Since the mid-1950s, with new or improved fishways and fishlifts, shad numbers have increased dramatically, especially in the Connecticut and Merrimack rivers. In many years, nearly 400,000 fish have been passed at the Holyoke Fish Lift on the Connecticut River (see Figure 3). The species was apparently extirpated from the Blackstone Drainage in the

mid-1800s. Reintroductions made during the late 1970s in the Charles River have had minimal success.

NOTES. American Shad are a commercially important species, with many tons netted in marine waters annually. In freshwater, shad are a popular sport fish. The recent recovery of shad in the Connecticut Basin has also benefited the Alewife Floater, *Anodonta implicata.* This freshwater mussel, which attaches to the gills of herrings as a larvae, was known only from below Hartford, Connecticut, before 1970. However, by 1984 and coincidental with the shad's range extension, it was found as far north as Bellows Falls, Vermont.

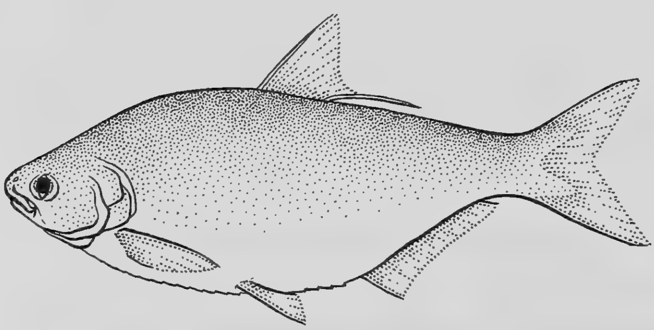
REFERENCES. Bigelow and Schroeder 1953, Clayton et al. 1978 (review); Stevenson 1899, Belding 1921, Reback and DiCarlo 1972, Grosslein and Azarovitz 1982 (distribution); Smith 1985 (freshwater mussel); Whitehead 1985 (review); O'Leary and Kynard 1986 (behavior, migration); Meyer 1999 (recovery and declines).

Gizzard Shad

Native

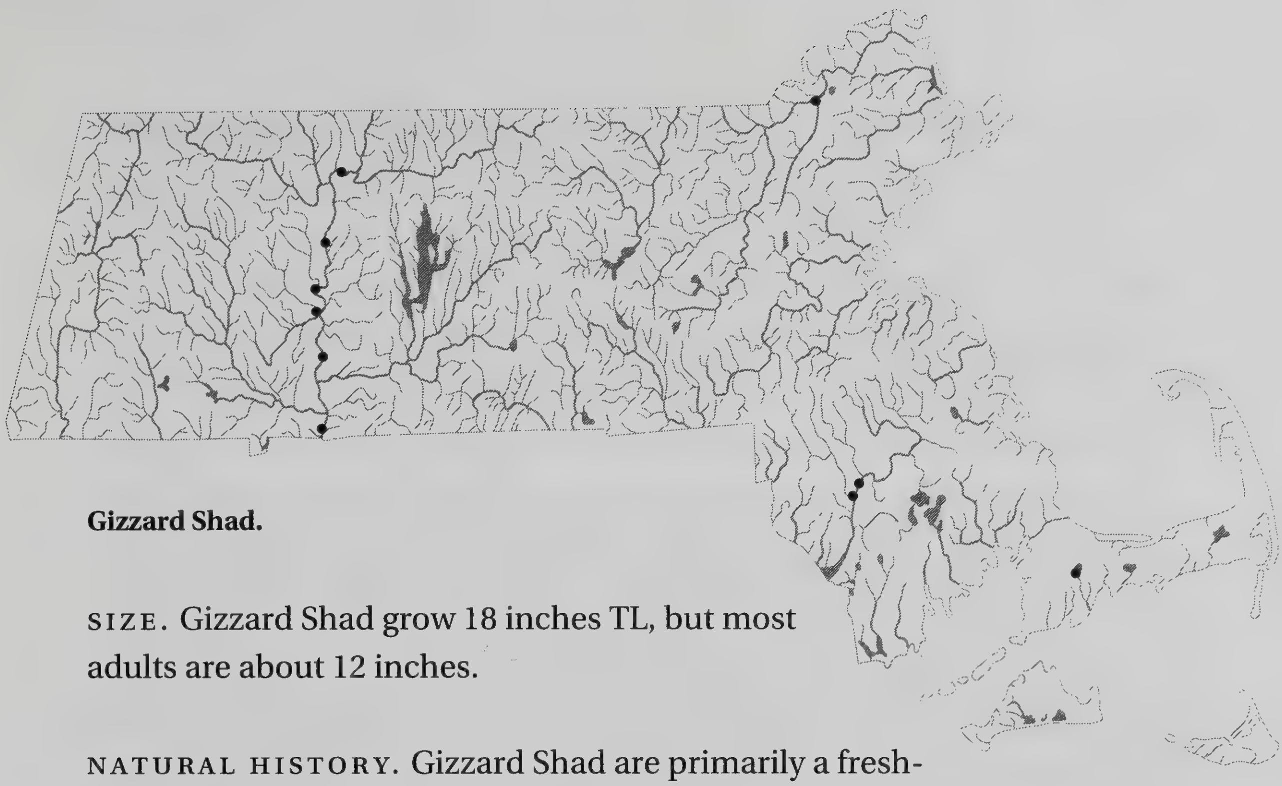
Dorosoma cepedianum (Lesueur 1818)

PLATE 7



IDENTIFICATION. Gizzard Shad have an elongated last dorsal fin ray and a slightly inferior mouth, which distinguishes them from all other Massachusetts herrings. This species also has more than 100 gill rakers, while other local herrings have fewer than 75.

SELECTED COUNTS. D 10–13; A 24–36; Scales 52–70; GR (total) 100–400 that increase in number with age.



Gizzard Shad.

SIZE. Gizzard Shad grow 18 inches TL, but most adults are about 12 inches.

NATURAL HISTORY. Gizzard Shad are primarily a freshwater species, but they may occasionally be found in marine environments. This shad lives in a wide range of habitats, including large rivers, swamps, reservoirs, canals, and estuaries. In these varied habitats, it generally swims in midwater and is usually found in quiet areas with low current. Spawning occurs in mid- to late spring, apparently in streams or over shallow bars in lakes. Gizzard Shad spawn in groups near the surface, and the fertilized eggs slowly sink and stick to the substrate or other underwater objects. As in other herring, female Gizzard Shad carry large numbers of eggs; over 400,000 have been recorded from large individuals. Gizzard Shad feed almost exclusively on phytoplankton, which they filter out of midwater using their numerous gill rakers. Juveniles include some zooplankton in their diet. The Gizzard Shad is well named because it has a muscular, thick-walled stomach that processes food much like the gizzard of a bird.

DISTRIBUTION AND ABUNDANCE. Gizzard Shad are found over much of middle North America west of the Hudson River. In Massachusetts, Gizzard Shad were first discovered in May and June of 1985 and 1986, when over 70 (14 to 18 inches TL) were observed at the Holyoke Fish Lift on the Connecticut River. Reproduction was confirmed in July 1986 when a 2-inch TL juvenile was collected in the Easthampton Oxbow of the Connecticut River. Since 1987, numbers have increased at the Holyoke Fish Lift: 95 (1988); 294 (1989); 950 (1990); 486 (1991); to 2,065 in 1995. By the early summer of 2000 the population had exploded and 32,000 gizzard shad were counted as they

passed dams on the Connecticut River. In addition, 10 or so specimens have been taken each year at the Merrimack River fishways since the first was caught in October 1985 (J. O'Leary, pers. comm.). We have seen a photograph of an adult taken on hook and line from Mashpee-Wakeby Pond in the spring of 1989. In 1991, an adult was found in the Taunton River above the Berkley Bridge; in 1997, young were also seen in these waters (S. Hurley, pers. comm.).

NOTES. The Gizzard Shad is the only freshwater fish species that has naturally expanded its range into Massachusetts in recent years. Gizzard Shad were found for the first time in tributaries to Long Island Sound in the early 1970s. By 1976, commercial fishermen were catching them near the mouth of the Connecticut River, and they were collected 16 miles up the Connecticut River in 1984. Massachusetts populations are believed to have originated from the Hudson River estuary.

REFERENCES. O'Leary and Smith 1987 (Massachusetts); Buerkett and Kynard 1993 (Taunton records); Miller 1960 (systematics and biology); Scott and Crossman 1973, Whitehead 1985 (general reviews).

Anchovy Family

Engraulidae

Anchovies are members of the Clupeiformes, or herringlike fishes, and are most easily distinguished from the true herrings by the presence of an overhanging snout and a long upper jaw that usually reaches well behind the eye. The anchovy family, with about 140 species, has a worldwide distribution in temperate and tropical inshore marine environments. Many anchovies can tolerate a wide range of salinities and enter the brackish or freshwaters of coastal rivers and streams. A number of tropical species, especially in the Amazon Basin, live their entire lives in freshwater. Anchovies form an important worldwide fishery, with from 4 to 13 million tons taken annually. However, some populations have crashed due to overfishing and climatic changes. Decreases in the abundance of anchovies off Peru drastically affected the local fish-eating birds and the human economy. Anchovies are harvested for human and animal consumption, bait, and a wide variety of other uses.

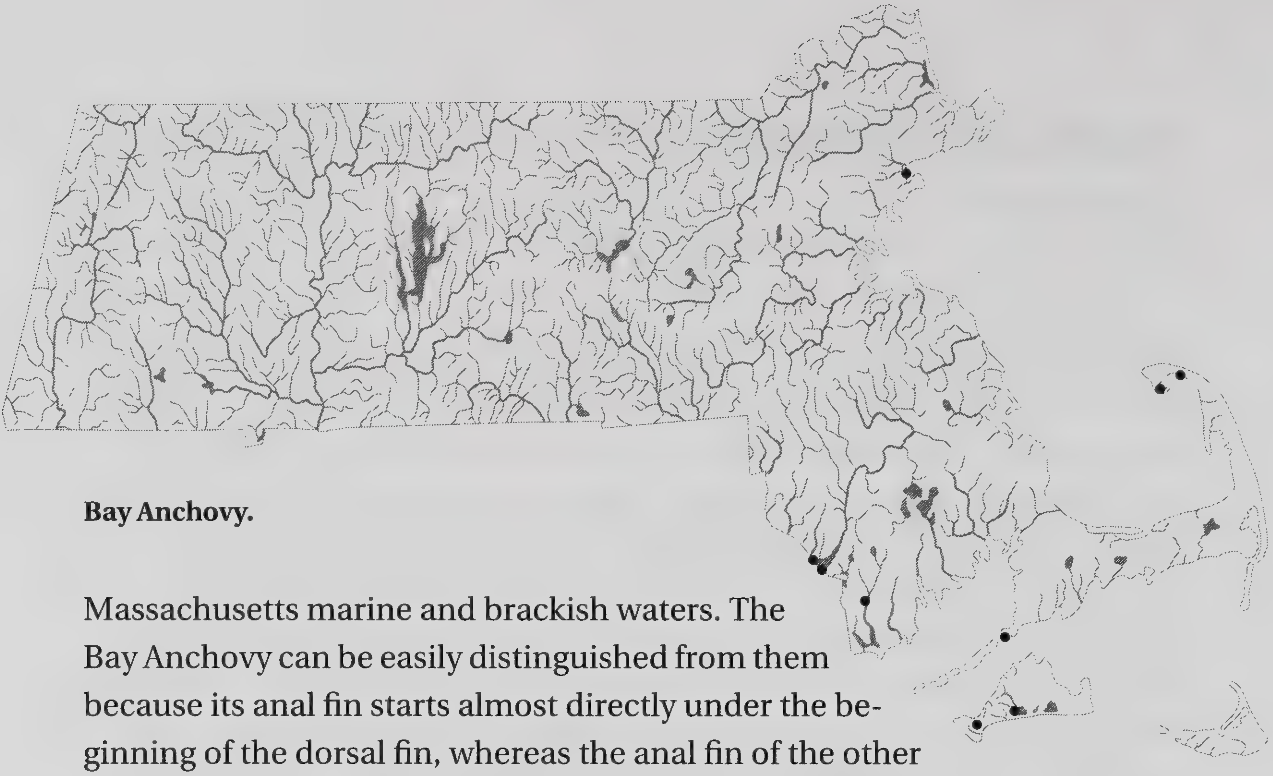
REFERENCES. Hildebrand 1963, Whitehead et al. 1988 (reviews).

Bay Anchovy

Native

Anchoa mitchilli (Valenciennes 1848)

IDENTIFICATION. Anchovies resemble elongated small herrings; however, the mouth of the anchovy is large, subterminal, and located well under a projecting snout. The upper jaw reaches almost to the posterior edge of the gill cover, and the anal fin starts almost directly under the beginning of the dorsal fin. Two other species of anchovies, the Striped Anchovy *Anchoa hepsetus* and the Silver Anchovy *Engraulis eurystole,* have been found in



Bay Anchovy.

Massachusetts marine and brackish waters. The Bay Anchovy can be easily distinguished from them because its anal fin starts almost directly under the beginning of the dorsal fin, whereas the anal fin of the other two species originates under the end of the dorsal fin (or well behind).

SELECTED COUNTS. D 14–16; A 23–30; GR (lower) 20–26.

SIZE. Adults are usually less than 4 inches TL.

NATURAL HISTORY. The Bay Anchovy is primarily a marine species, but it moves seasonally into estuaries and bays to spawn. Where abundant south of Cape Cod, they form large schools and are important food for many of the larger fishes, such as the Striped Bass and Bluefish *Pomatomus saltatrix*. Anchovies are mostly filter feeders and strain a variety of zooplankton from the water with their gill rakers. Spawning occurs from late spring though summer; eggs have been found in Cape Cod Bay from June through August. The eggs and larvae are pelagic.

DISTRIBUTION AND ABUNDANCE. The Bay Anchovy is found in Atlantic coastal waters from Maine to southern Mexico. In Massachusetts, it is rare north of Cape Cod, but small numbers of this anchovy periodically enter many of the estuaries south of Cape Cod. During visits to the upper estuaries, they occasionally enter freshwater, usually during the late summer and early fall. Bay Anchovies are never as abundant in Massachusetts waters as they are farther south where their biomass may be higher than that of any other fish species.

REFERENCES. Bigelow and Schroeder 1953, Hildebrand 1963, Whitehead et al. 1988 (identification, systematics, natural history); Collette and Hartel 1988 (Mass. Bay records); Scherer 1984 (eggs and larvae in Cape Cod Bay); Vouglitois et al. 1987 (life history, populations).

Carp and Minnow Family

Cyprinidae

The true minnows are found almost worldwide in temperate and tropical regions but are absent from South America, Australia, and Madagascar. Cyprinids belong to the group of fishes called the Ostariophysi (which includes characins, catfishes, suckers, loaches, and electric eels) that have a specialized modification of the four or five anterior vertebrae. This modification, called the Weberian Apparatus, links the ear to the swim bladder and is used to amplify sound. The Cyprinidae contains more species than any other fish family: some 210 genera and more than 2,000 species. As adults, they range in size from 1 inch to over 9 feet. The 230 species found in North America have many life history strategies, from carnivore to mud-eating detritivore, and they live in the slowest rivers and largest lakes to the fastest hill-stream torrents.

Identification of minnows, especially juveniles, may be difficult and great care must be taken. Additional confusion results from the many common names applied to them. Chub, shiner, dace, and minnow are often used interchangeably, and sometimes the terms are used to refer to any of the small, bait-sized fishes of other families. The true minnows, however, can be identified by the lack of teeth in their oral jaws, their well-developed pharyngeal teeth, and one dorsal fin. Male minnows develop contact organs or tubercles during the breeding season. These hardened, pointed structures are most often found on the snout and pectoral fins. They vary in size and placement among species and are used during breeding for territorial aggression or sexual stimuli.

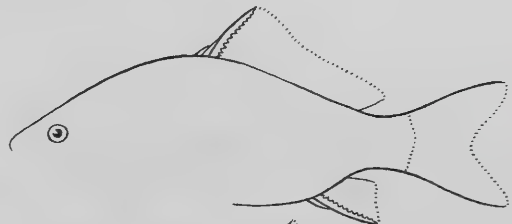
Minnows are well known to both anglers and aquarists who use them as bait or keep them as pets. Millions of bait-minnows are raised and sold each year, and millions of aquarium minnows, such as barbs and rasboras, can be found in pet stores. As noted in the following accounts, at least three non-native minnow species have been established in Massachusetts through bait-bucket introductions, including the Bluntnose Minnow, Fathead Minnow, and Rudd. In addition, the Emerald Shiner, *Notropis atherinoides,* and the Grass Carp, *Ctenopharyngodon idella,* have been used as live bait or documented from the wild but are not reproducing in the state. In the fall of 1997, the Cutlips Minnow, *Exoglossum maxillingua,* was found

in the Farmington River and then proven to be reproducing in late 2001. Species accounts for these three species are not included in this book, but they can be identified by using the keys.

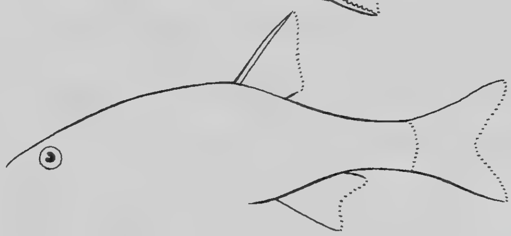
REFERENCES. Cavender and Coburn 1992, Fink and Fink 1981, Coburn and Cavender 1992, Mayden 1989 (relationships); Winfield and Nelson 1991 (overview).

Key to Massachusetts Carp and Minnows

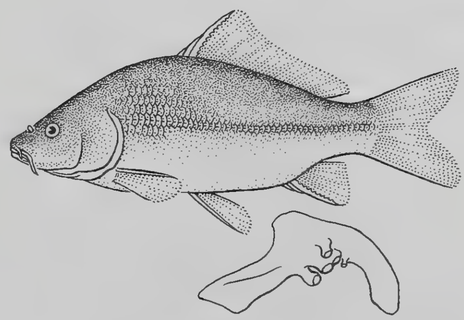
1a. Dorsal and anal fins each with a stout serrated "spine" at anterior edge; more than 15 dorsal fin rays. Go to 2.



1b. Dorsal and anal fins without a stout serrated "spine" at anterior edge; fewer than 11 dorsal fin rays. Go to 3.

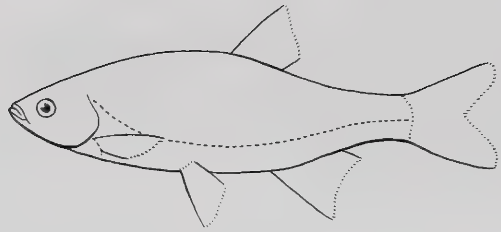


2a. Upper jaw with two fleshy barbels on each side; lateral line scales more than 35 (scales few or absent in "Leather" or "Mirror" forms of this species); pharyngeal teeth large and flattened and in 3 rows. Common Carp, *Cyprinus carpio,* page 104, Plate 11.

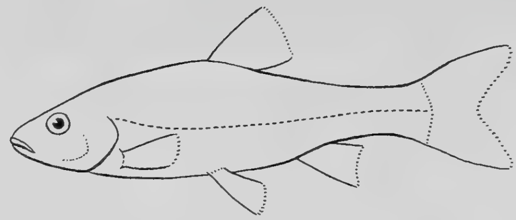


2b. Upper jaw without fleshy barbels; lateral line scales less than 30; pharyngeal teeth not flattened and in 1 row. Goldfish, *Carassius auratus,* page 100, Plate 10.

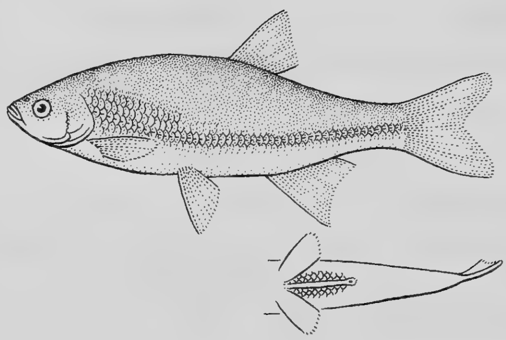
3a. Usually over 11 anal rays; deep-bodied and slab-sided as adults; lateral line deeply decurved following ventral outline of body. Go to 4.



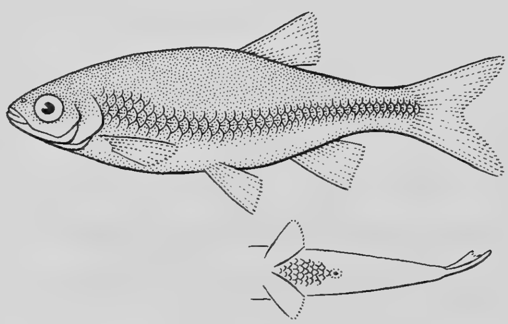
3b. Usually fewer than 10 anal rays (except in Emerald Shiner, *Notropis atherinoides,* which has 10 to 11); body elongate and usually not slab-sided; lateral line never deeply decurved. Go to 5.



4a. Belly between pelvic and anal fins with fleshy, scaleless keel; 18 to 22 gill rakers; 9 to 12 scales above lateral line; pharyngeal teeth in 1 row (0,5–5,0). Golden Shiner, *Notemigonus crysoleucas,* page 110, Plate 9.



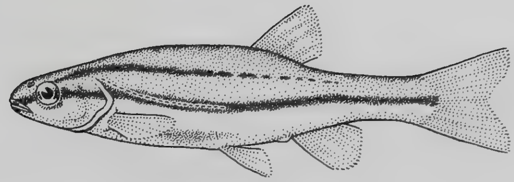
4b. Belly behind pelvic fins fully scaled, without fleshy keel; 10 to 13 gill rakers; 7 to 8 (seldom 9) scales above lateral line; pharyngeal teeth in two rows (3,5–5,3). Rudd, *Scardinius erythrophthalmus,* page 128, Plate 8.



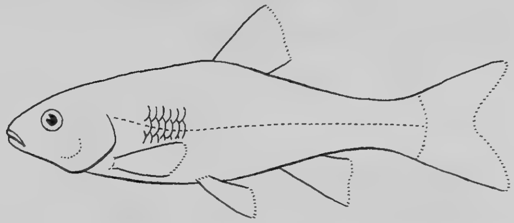
5a. Lower lip divided into three lobes, the middle tonguelike. Cutlips Minnow, *Exoglossum maxillingua.* See family account (not illustrated).

5b. Lower lip normal, not as above (not illustrated). Go to 6.

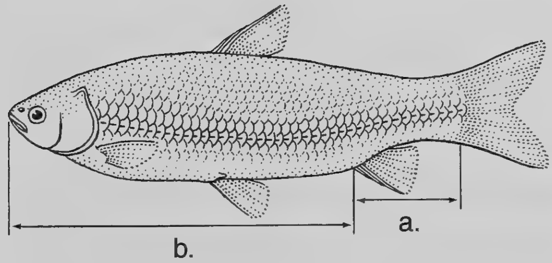
6a. Scales small, barely visible, 75 or more in lateral line; body with 2 dark lateral stripes. Northern Redbelly Dace, *Phoxinus eos,* page 118, Plate 12.



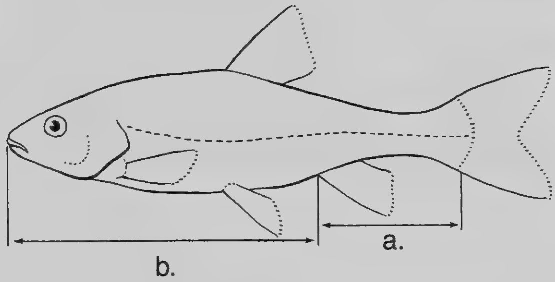
6b. Scales 65 or fewer in lateral line series; body with either one dark stripe on side or none. Go to 7.



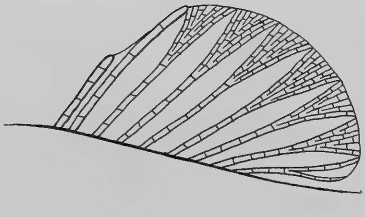
7a. Anal fin set far back on body, **a** goes into **b** more than 3 times. Grass Carp, *Ctenopharyngodon idella.* See family account.



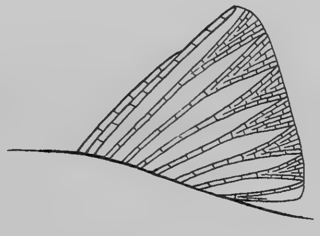
7b. Anal origin close to or under dorsal fin, **a** goes into **b** 2.5 times or fewer. Go to 8.



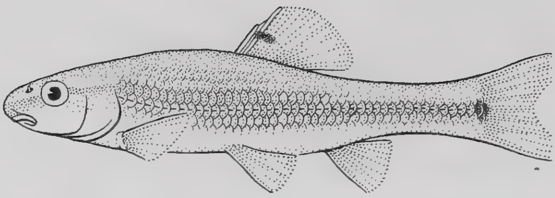
8a. First dorsal ray short, slightly thickened and separate from first principal ray (in adults); predorsal area tends to be flattened, and the scales are small and crowded. Go to 9.



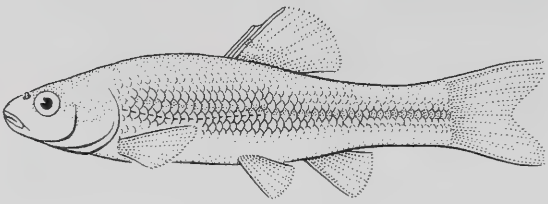
8b. First dorsal ray thin and tightly bound to first principal ray; body usually rounded and scales moderately crowded or well spaced out. Go to 10.



9a. Mouth nearly horizontal and overhung by snout; lateral line complete, extending to base of tail; a pigment spot on anterior dorsal fin rays and at base of caudal fin. Bluntnose Minnow, *Pimephales notatus*, page 120, Plate 23.



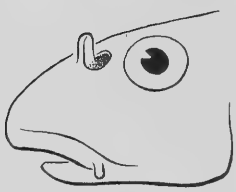
9b. Mouth oblique and not overhung by snout; lateral line incomplete, not extending to base of tail; no noticeable pigment markings. Fathead Minnow, *Pimephales promelas*, page 122, Plate 24.



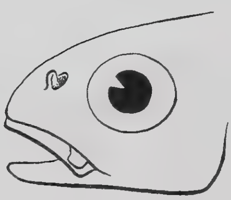
10a. Barbel present either at corner of mouth or in groove behind maxilla (not illustrated; see key Figures 11a and 11b). Go to 11.

10b. Barbels absent (not illustrated). Go to 15.

11a. Barbel at corner of mouth. Go to 12.

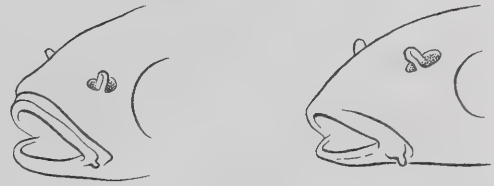


11b. Barbel leaflike and in groove behind maxilla. Go to 14.



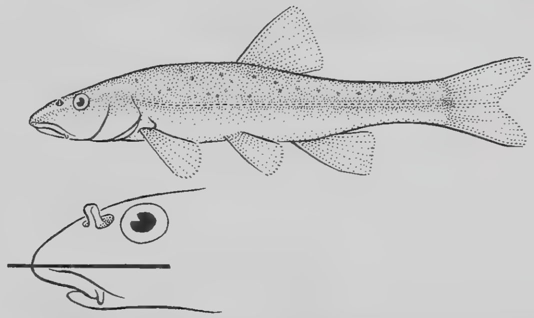
12a. Upper jaw protractile, with distinct groove between premaxilla and snout. Lake Chub, *Couesius plumbeus*, page 102, Plate 13.

12b. Upper jaw not protractile, no groove between premaxilla and snout. Go to 13.

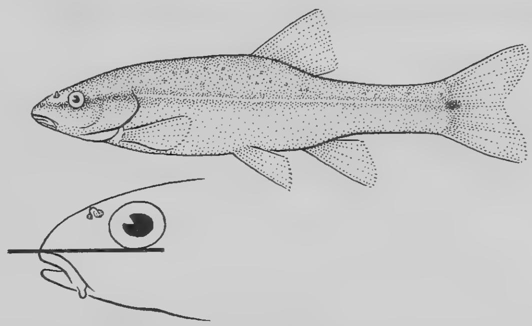


12a 12b

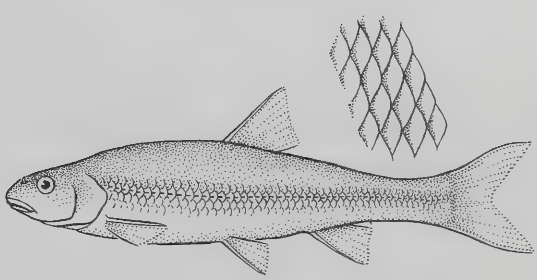
13a. Snout projecting beyond mouth; eye above highest point of upper jaw. Longnose Dace, *Rhinichthys cataractae*, page 126, Plate 22.



13b. Snout not projecting well beyond mouth; eye and highest point of upper jaw at about the same level. Blacknose Dace, *Rhinichthys atratulus*, page 124, Plate 21.

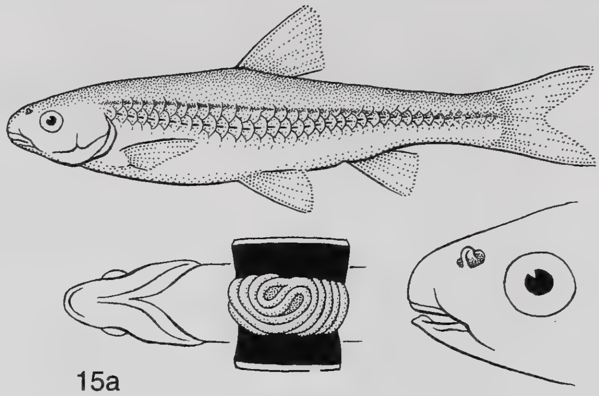


14a. Lateral line scales fewer than 50; most body scales with dense pigment at anterior edge; no black spot at leading edge of dorsal fin. Fallfish, *Semotilus corporalis*, page 132, Plate 18.



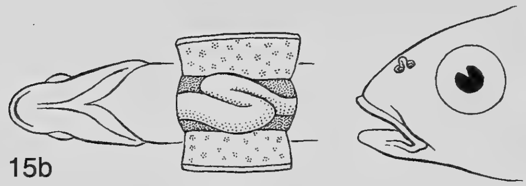
14b. Lateral line scales more than 52; anterior edge of scales without dark pigment; dark spot usually present at anterior base of dorsal fin. Creek Chub, *Semotilus atromaculatus*, page 130, Plate 19.

15a. Lining of body cavity black; intestine long and coiled; small bump at tip of lower jaw. Eastern Silvery Minnow, *Hybognathus regius*, page 106, Plate 14.



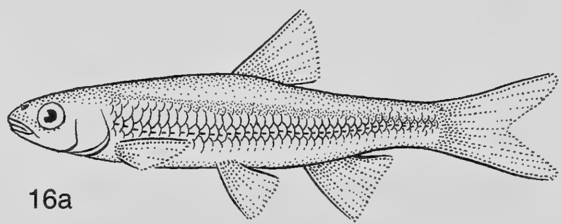
15a

15b. Lining of body cavity silvery, with or without dark speckles; intestine short, less than twice standard length; no bump at tip of lower jaw. Go to 16.



15b

16a. Anal fin with 10 to 11 rays. Emerald Shiner, *Notropis atherinoides.* See family account.

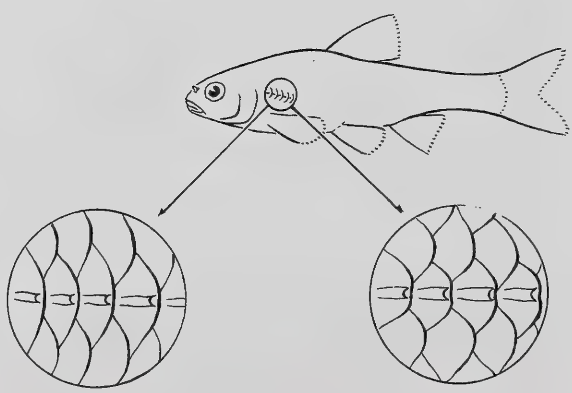


16a

16b. Anal fin with 7 to 9 rays (not illustrated). Go to 17.

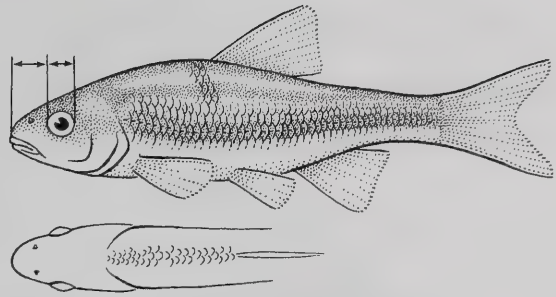
17a. Scales along anterior portion of lateral line deeper than wide. Go to 18.

17b. Scales along anterior portion of lateral line equally deep as wide. Go to 19.

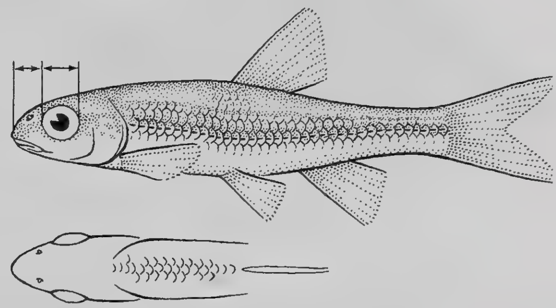


a b

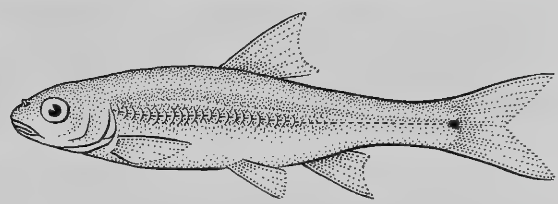
18a. Predorsal scales over 22; anal fin usually with 9 rays; more than 5 scale rows above lateral line; no V-shaped dark pigment behind anus; eye diameter less than snout length. Common Shiner, *Luxilus cornutus*, page 108, Plate 17.



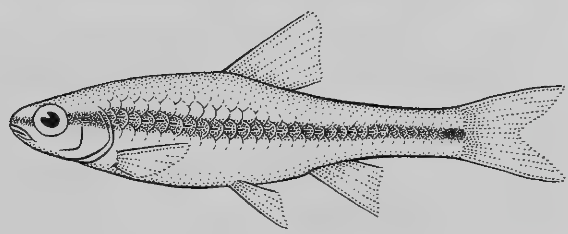
18b. Predorsal scales approximately 15; anal fin usually with 7 rays; less than 5 scale rows above lateral line; V-shaped area of dark pigment behind anus; eye diameter greater than snout length. Mimic Shiner, *Notropis volucellus*, page 116, Plate 16.



19a. Usually 8 anal fin rays; dorsal, anal, and pectoral fins typically falcate; no dark band along snout and body (except young may have a weak band). Spottail Shiner, *Notropis hudsonius*, page 114, Plate 15.



19b. Seven anal fin rays; dorsal, anal, and pectoral fins not falcate; dark band through eyes and across snout. Bridle Shiner, *Notropis bifrenatus*, page 112, Plate 20.

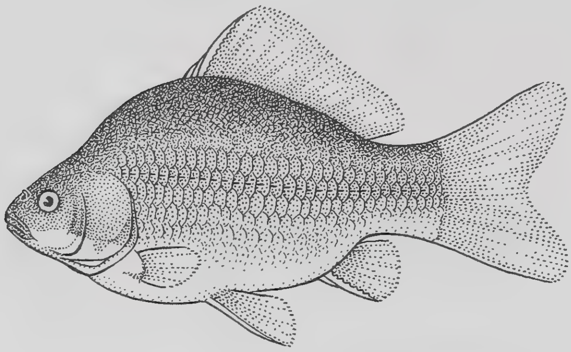


Goldfish

Introduced

Carassius auratus (Linnaeus 1758)

PLATE 10

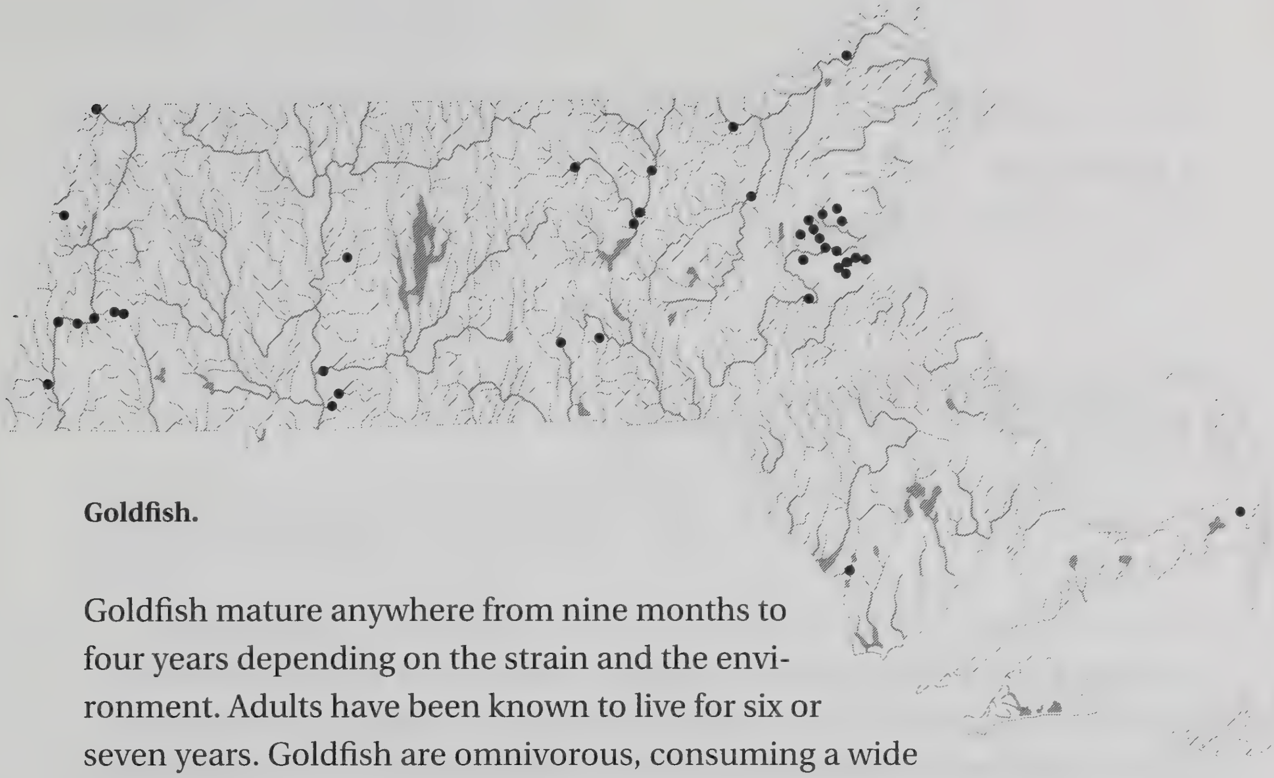


IDENTIFICATION. Like carp, Goldfish are heavy-bodied minnows with large scales, a long dorsal fin, and hardened and serrated anterior anal and dorsal rays. Goldfish lack the mouth barbels found in carp, and their pharyngeal teeth are in one row (see key Figure 2b). The natural goldfish color is olive to brassy; however, propagated fish may range from all gold to orange or to mixtures of red, white, black, and orange. Introduced populations may gradually revert to the natural wild color.

SELECTED COUNTS. D i,15–19; A i,5–6; Scales 25–31; PT 0,4–4,0.

SIZE. Goldfish can grow to be a foot or more in length but most Massachusetts specimens are only 5 to 8 inches TL. The largest specimen that we have seen is 13 inches TL (215 mm SL) and was collected from the Charles River, Cambridge.

NATURAL HISTORY. Introduced Goldfish seem to do best in smaller ponds with abundant aquatic vegetation. We have rarely found them in flowing waters. Goldfish spawn in the spring (May–June in New York). Two or more males follow single females over aquatic vegetation to spawn. The spawning behavior is fast and accompanied by aggressive splashing. In fact, it can be quite violent; delicate, ornamental strains are often damaged while reproducing in aquaria. In the wild, eggs are scattered over the bottom vegetation and hatch in three to four days. In most populations, female goldfishes are more abundant than males; there are 13 to 36 males reported for each 100 females. Males are also smaller and grow more slowly than females.



Goldfish.

Goldfish mature anywhere from nine months to four years depending on the strain and the environment. Adults have been known to live for six or seven years. Goldfish are omnivorous, consuming a wide range of food types including larval and adult aquatic insects, mollusks, crustaceans, worms, and vegetation.

DISTRIBUTION AND ABUNDANCE. Goldfish are native to eastern Siberia, China, and Korea, but have been introduced worldwide. Introduced populations are now found in every state in the United States, except Alaska, and in three Canadian provinces. Goldfish were the first exotic fish to be brought to North America. In his 1842 review of New York fishes, J. DeKay reports that the first releases were as early as the late 1600s. Goldfish were common and well known in the waters around Brookline, Cambridge, and Brighton, Massachusetts, before 1839, but the species was not noted in western Massachusetts prior to 1941. We have found specimens in scattered areas throughout the state, usually near urban centers. The species is probably more widely distributed than our data suggest since Goldfish are common in farm and golf course ponds, which we did not survey.

NOTES. Goldfish and Common Carp hybridize and produce fertile offspring; however, we have not found hybrids in Massachusetts.

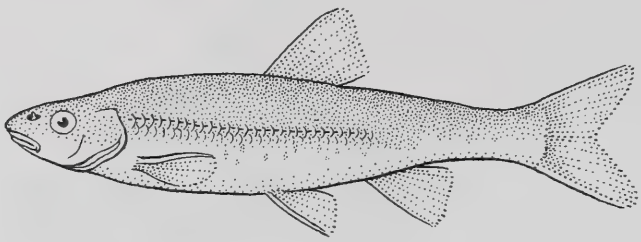
REFERENCES. Breder and Rosen 1966 (reproduction); Courtenay and Stauffer 1984, Storer 1839, DeKay 1842 (introductions); Scott and Crossman 1973 (Canada); Smith 1985 (NY).

Lake Chub

Native, State Endangered

Couesius plumbeus (Agassiz 1850)

PLATE 13



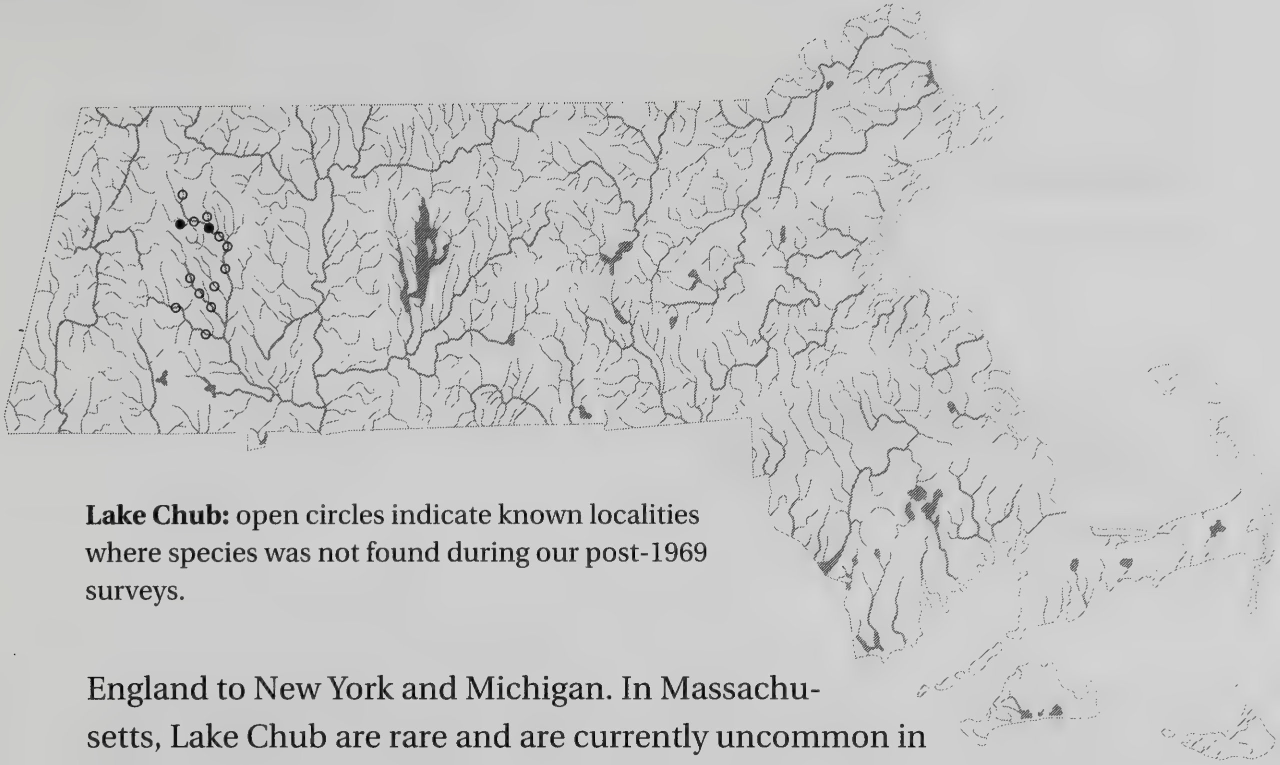
IDENTIFICATION. Lake Chub are elongate, moderately round-bodied minnows with a small but well-developed conical barbel at the posterior end of their upper jaw. The snout is completely separated from the upper lip by a continuous deep groove, and the mouth is slightly subterminal. Breeding males have a hint of orange wash on the pectoral fins and face.

SELECTED COUNTS. D 8; A 8; Scales 10/53–70/7; PT 2,4–4,2.

SIZE. Adults are between 3 and 4 inches TL, but specimens up to 9 inches TL have been found outside of Massachusetts.

NATURAL HISTORY. Due to its rarity, almost nothing is known about the behavior of Lake Chub in Massachusetts. Relatively few studies of Lake Chub have been conducted, and those that are available generally pertain to lake habitats, which the species prefers. In Massachusetts, the Lake Chub has been found only in moderate to fast-flowing, clear, cold streams. It prefers areas of little or no vegetation with gravel and rubble bottoms. Lake Chub spawn during late spring to early summer. In the Connecticut Lakes Region of New Hampshire, spawning occurs in early July. Nests are not built; eggs are simply deposited on rocky substrate and left unguarded. In British Columbia, Lake Chub mature in their third year and seldom live more than five years. Females grow faster and live longer than males. Lake Chub feed on a variety of stream invertebrates, including aquatic insects and crustaceans. Occasionally, they will eat small fishes and algae.

DISTRIBUTION AND ABUNDANCE. Lake Chub are found throughout Canada and at scattered localities in the United States from northern New



Lake Chub: open circles indicate known localities where species was not found during our post-1969 surveys.

England to New York and Michigan. In Massachusetts, Lake Chub are rare and are currently uncommon in the upper portions of the Westfield River. As late as 1952, Lake Chub were common in the Middle and West branches of the Westfield; however, surveys conducted between 1977 and 1990 have failed to locate this species in the Middle Branch and have found only a few specimens in the upper East and West branches. The Westfield population is disjunct; the nearest population is in the northern Connecticut River Basin of Vermont and New Hampshire.

NOTES. The Massachusetts population occupies the southeastern-most part of the species' range. Lake Chub populations at the southern extremes of its range are often disjunct, and several of these populations may have been extirpated. Lake Chub are currently listed as State Endangered by the Massachusetts Division of Fisheries and Wildlife. Their listing is due to a documented decline over the last 30 years. This species has been collected at only a few of the many sites surveyed in the Westfield Drainage since 1977. The reasons for its decline are unknown.

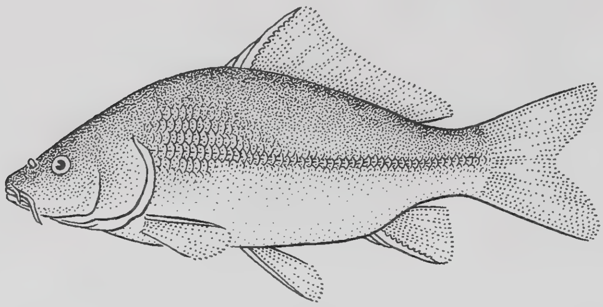
REFERENCES. Brown et al. 1970 (breeding); Halliwell 1978 and 1989 (surveys); McCabe 1942, 1943, Mullan 1952 (Westfield records).

Common Carp

Introduced

Cyprinus carpio Linnaeus 1758

PLATE 11

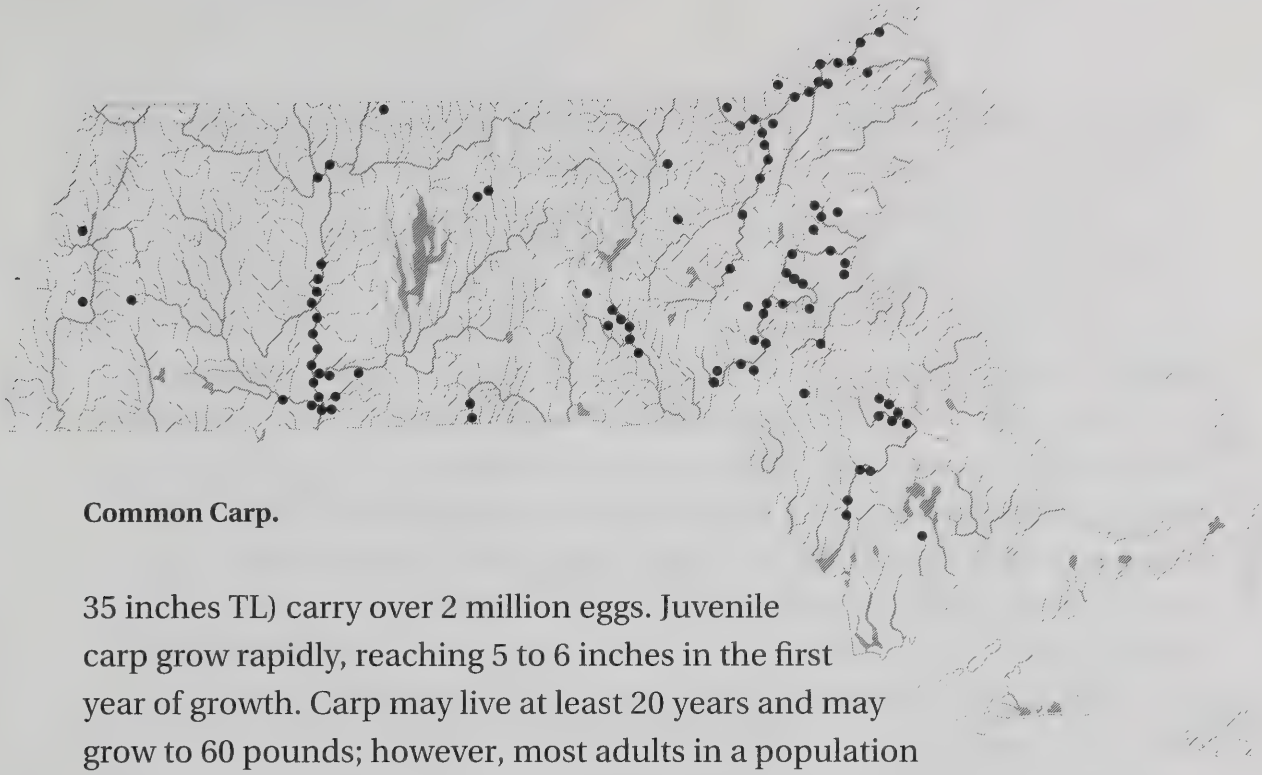


IDENTIFICATION. Common Carp are large, robust-bodied minnows with long dorsal fins. The first rays of the dorsal and anal fins are modified into stout, serrated spines. Two pairs of barbels on the upper jaw separate Common Carp from Goldfish. The scale number is variable: in a variety called "leather carp," scales may be absent; in another called "mirror carp," scales are enlarged and scattered, but the typical form has about 35 large scales. The pharyngeal teeth in carp are heavy and molarlike and more developed than in Goldfish.

SELECTED COUNTS. D i,18–23; A i,4–5; Scales 32–41(0); PT 1,1,3–3,1,1.

SIZE. Most adult Common Carp are around 2 feet TL, but they can grow much larger. A 44.1 pound carp angled from the Connecticut River in 1993 is the current Massachusetts state record.

NATURAL HISTORY. Common Carp usually inhabit large, slow-flowing rivers, large ponds, and lakes with abundant aquatic vegetation. Carp winter in deep water but move inshore during spring. Spawning carp are often seen swimming and rolling with their backs and dorsal fins out of the water when water temperatures exceed 59°F, and spawning continues from late spring into late summer. Carp spawn in inshore areas with aquatic or seasonally flooded vegetation. Groups of three to four males spawn with each female and their behavior causes splashing and uprooting of vegetation. The eggs are randomly broadcast and adhere to vegetation until they hatch in 4 to 12 days, depending on temperature. Female carp carry an enormous number of eggs, with fecundity increasing with size. Large females (about



Common Carp.

35 inches TL) carry over 2 million eggs. Juvenile carp grow rapidly, reaching 5 to 6 inches in the first year of growth. Carp may live at least 20 years and may grow to 60 pounds; however, most adults in a population weigh 4 to 15 pounds and are four to eight years old. Carp are omnivorous, eating great quantities of animal and vegetable matter. Their diet has been found to include leaves, roots, stems and seeds of aquatic plants, seeds of terrestrial plants, worms, leeches, crustaceans, mollusks, and occasionally fish eggs.

DISTRIBUTION AND ABUNDANCE. Common Carp are native to almost all of Eurasia, but the exact native range is unknown due to pre-Roman introductions. They were brought to North America as early as 1831 and through subsequent introductions and natural dispersal they are now found in all of the lower 48 states, Hawaii, and southern Canada. Common Carp were first distributed in Massachusetts by the U.S. Bureau of Fisheries in 1880. Today, Common Carp are found in many areas, particularly the Merrimack, Concord, Connecticut, Taunton, and Blackstone rivers and in a number of larger lakes and ponds. Carp are at times common; over 20,000 were killed by dropsy (caused by an *Aeromonas* bacteria) over a short period in the Merrimack River in the late 1970s. Our records probably underestimate the range and abundance of this species since it is normally not taken with the small seines and electrofishing gear used during our surveys. Koi, which are often found in garden ponds, are an ornamental variety of Common Carp and are not Goldfish.

NOTES. It became evident that Common Carp sometimes interacted in a negative way with its new environment as early as the turn of the century.

Most ecological problems associated with carp center around its alteration of habitat during foraging and spawning. Taylor et al. (1984:336) state, "Deterioration in native fish populations has often accompanied the spread and buildup of carp populations...Evidence for impact is strong in the sense that, in numerous independent studies, increases in carp population and concomitant changes in habitat structure have been repeatedly associated with declines in or displacement of native assemblages. However, the multiplicity of effects possible—given the complex manner in which carp interact with virtually every physical and biological component of an ecosystem—has made it difficult to pinpoint simple cause-effect relationships." The habitat disturbance caused by carp has also contributed to a decline in the quality of waterfowl habitat in some areas. However, some authors state that the carp is not the "villain" that it has been long labeled (Jenkins and Burkhead 1993:275).

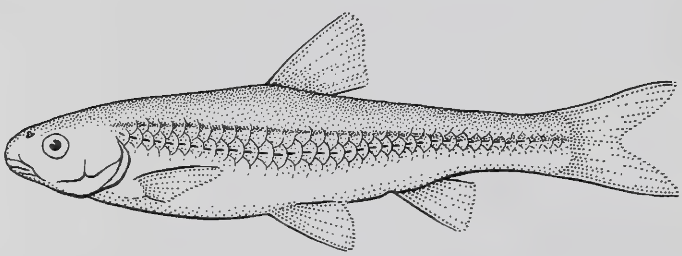
REFERENCES. Garman 1889, 1890, Courtenay and Stauffer et al. 1984 (introductions); MacCrimmon 1968, Cooper 1987 (biology); Taylor et al. 1984 (impacts); Mirick 1991 (MA).

Eastern Silvery Minnow

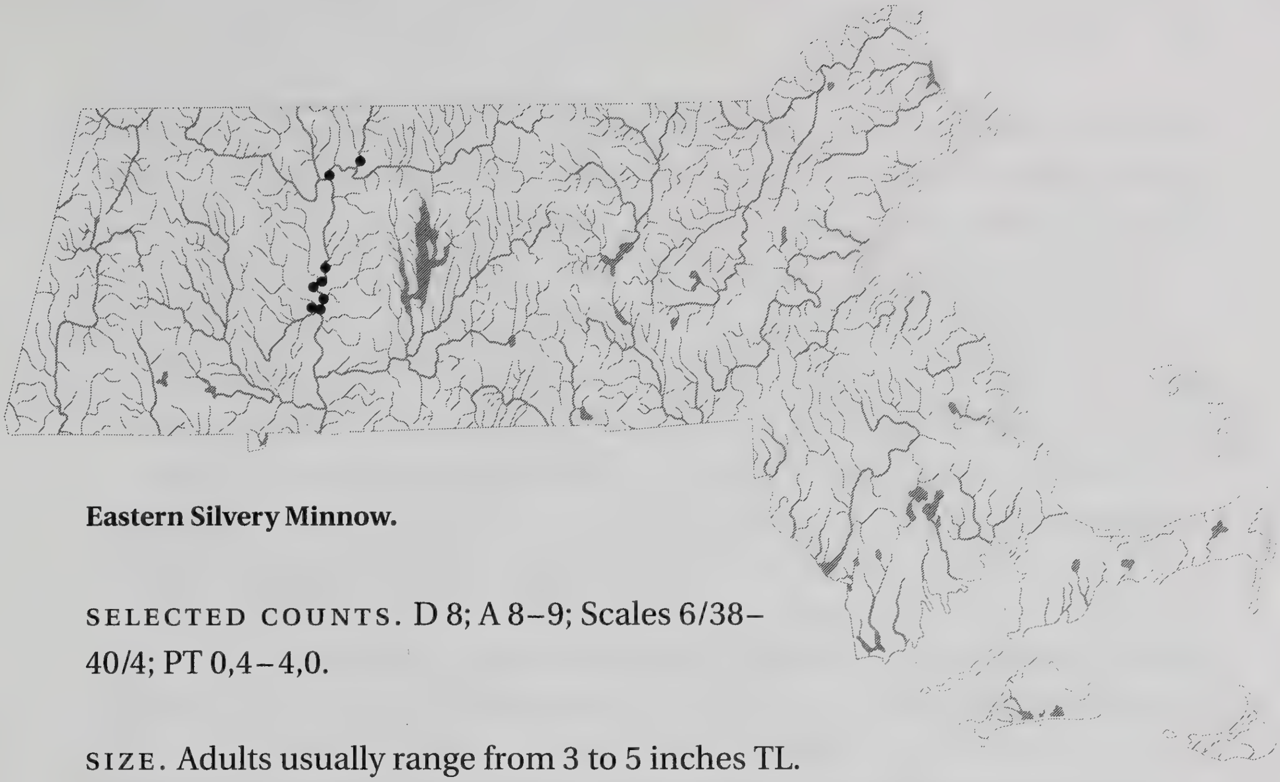
Native, State Special Concern

Hybognathus regius Girard 1856

PLATE 14



IDENTIFICATION. The Eastern Silvery Minnow is a rather stout, round-bodied shiner with medium-sized eyes. It is distinguished from other Massachusetts minnows by a combination of characteristics: a small, slightly subterminal mouth; a lower jaw with a fleshy knob at the tip; a black lining of the body cavity (peritoneum); a long, coiled intestine often seen through the belly wall; an expanded and flattened posterior extension of the skull (the basioccipital process); and 38 to 40 lateral line scales. It is silvery all over.



Eastern Silvery Minnow.

SELECTED COUNTS. D 8; A 8–9; Scales 6/38–40/4; PT 0,4–4,0.

SIZE. Adults usually range from 3 to 5 inches TL.

NATURAL HISTORY. Eastern Silvery Minnows characteristically inhabit wide, slow-moving rivers. They spawn diurnally in late spring at temperatures of 55° to 69°F in backwaters and lower reaches of tributary streams. This minnow is unique among northeastern cyprinids in that it lays nonadhesive eggs directly on bottom ooze in areas where emergent grasses and reeds provide cover. Females do not spawn until they are in their second year of life. Detailed studies of the diet of this species have not been carried out; however, filamentous algae and organic matter filtered from bottom ooze constitute the main food sources. Filtering is accomplished by modified papillae in the throat, and this filtered material is efficiently processed by the long, coiled intestine.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, this species is known only from the main stem of the Connecticut River north of the Holyoke Dam and in the lower Deerfield River. During the 1950s, Prof. Thomas J. Andrews found that this species was common over the flooded flats along the Connecticut River near Hadley. One of his seine collections contained nearly 100 specimens. However, surveys between 1978 and 1990 have recorded only a few individuals, usually collected along with the abundant Spottail Shiner.

NOTES. Since this minnow has apparently declined over the past 30 years, it is currently listed as a State Species of Special Concern. The reasons for

this decline in Massachusetts are uncertain; however, other members of the genus *Hybognathus* have been noted as declining in the Midwest due to siltation, pollution, and changes in water flow. In Massachusetts, the decline may be related to human manipulation of the natural river flow in the Connecticut Valley, as dams and pump storage facilities have been built. These types of water control practices may reduce or change the character of backwaters and spawning sites used by this minnow. Until recently, this species was considered a subspecies of the Mississippi Silvery Minnow, *Hybognathus nuchalis.*

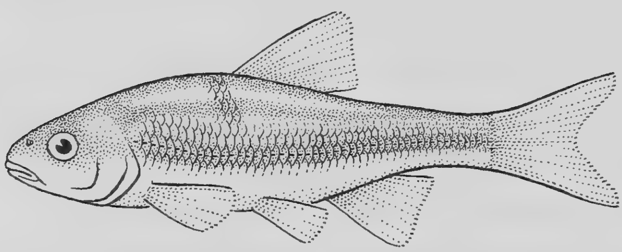
REFERENCES. Hlohowskyj et al. 1989 (filtering apparatus); Pflieger 1975 (declines, Missouri); Smith 1979, Warren and Burr 1989 (declines, Illinois); Raney 1939 (biology).

Common Shiner

Native

Luxilus cornutus (Mitchill 1817)

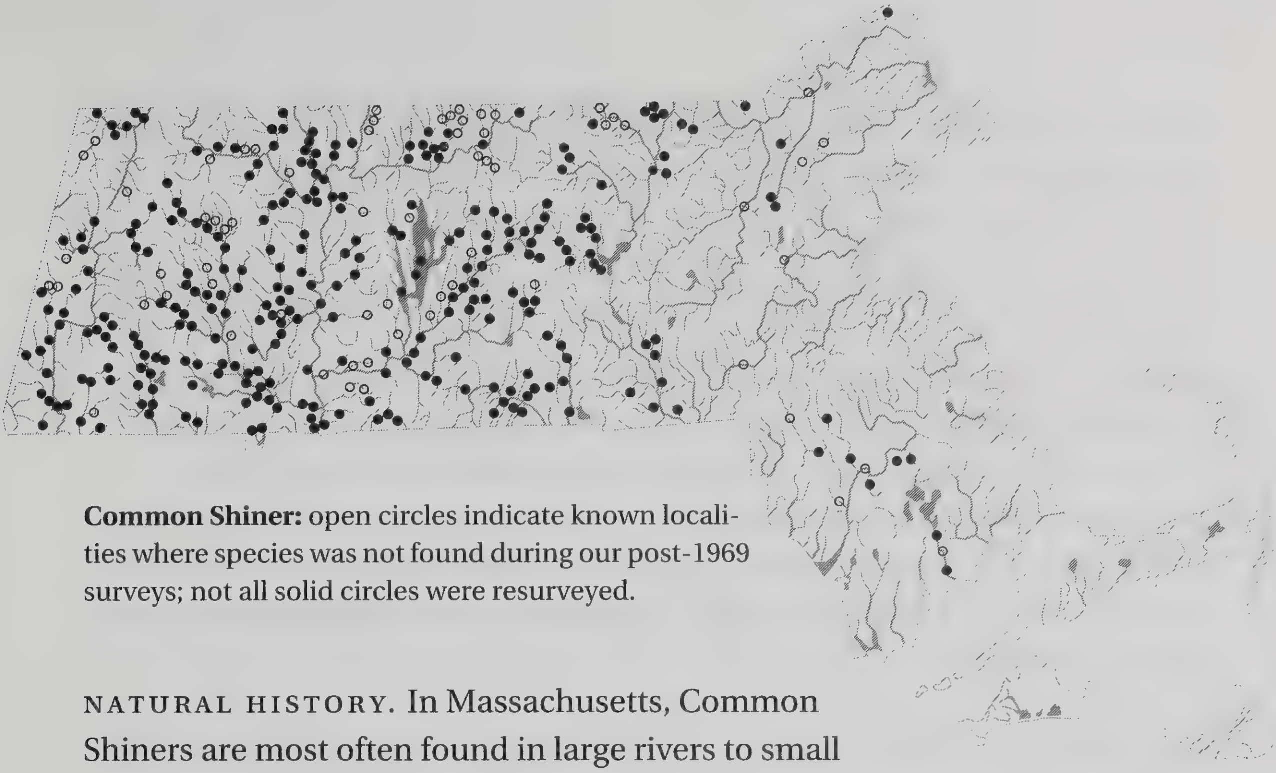
PLATE 17



IDENTIFICATION. Common Shiners are relatively deep-bodied minnows with a combination of 9 anal rays (rarely 8 or 10); deeper-than-wide anterior lateral scales (see key Figure 17a); and more than five scales above the lateral line. Common Shiners have distinctive horizontal stripes that appear in three bands; a pale middorsal band, a darker stripe below it, and a second pale stripe below that. In breeding males the stripes become golden and the body bronze; dark crescent-shaped marks appear on the body; the head darkens to blue-gray; and the fins darken with a pink to red distal edge.

SELECTED COUNTS. D 8; A 9 (8–10); Scales 7–8/38–44/5; PT 2,4–4,2.

SIZE. Common Shiners are a medium to large minnow, often reaching 5 to 6 inches TL; some Massachusetts specimens reach 7 inches TL (135 mm SL).



Common Shiner: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

NATURAL HISTORY. In Massachusetts, Common Shiners are most often found in large rivers to small streams with relatively clean water. Upstream spawning migrations begin in May as water temperatures reach 60° to 65°F. Males, which are much larger than females, establish and defend territories. Spawning sites are usually over gravel beds in running water where males sometimes excavate small depressions or use the spawning sites of other nest-building minnows. In Massachusetts, these nest builders include Fallfish and Creek Chub. This communal spawning behavior may result in hybrids between the Common Shiner and other species. Occasionally, up to 100 males may gather at a nest, and there is constant jostling for optimal positions on the site. The spawning act takes a fraction of a second, after which the participants drop downstream. Males and females may return many times to spawn with the same or different partners. Probably fewer than 50 eggs are laid at each spawning. Common Shiners feed mainly at the surface or in midwater, but they are opportunistic feeders. Aquatic insects, including both adults and larvae, are the primary food source, but small fishes and some plant material are also eaten occasionally.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, this minnow is most common from the Connecticut Drainage west, where it is found in all of the major Connecticut River tributaries and in the Hoosic and Housatonic rivers. In addition, there are scattered records from the Nashua, Merrimack, French, Blackstone, Taunton, and Charles river drainages. It is absent from all coastal streams, Cape Cod, and the Islands. As noted, the species may be declining.

NOTES. Common Shiners may have been more widely distributed in eastern Massachusetts in the past. For instance, we have seen historic specimens from the Charles Drainage collected at Waltham (late 1800s) and at Medfield (1962), but we have not observed this species in the Charles Drainage during any of our post-1975 surveys. Other eastern Massachusetts records, except from the Merrimack River Drainage, are scattered and rare. A recent comparison of the results of pre-1950 stream surveys to post-1975 surveys shows a considerable decline in the relative occurrence of the Common Shiner in the central portions of the state, particularly in the Millers and Chicopee drainages. Similar declines in this species have been noted within its midwestern range. This species was formerly placed in the genus *Notropis.*

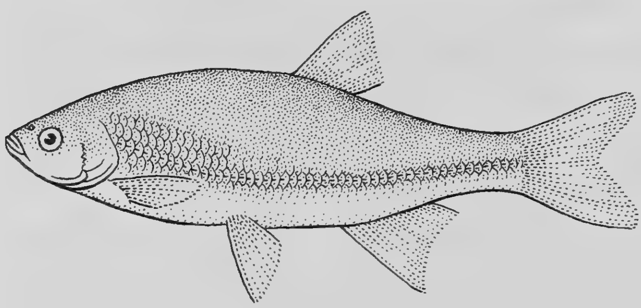
REFERENCES. Gilbert 1964 (description, distribution, relationships); Halliwell 1989 (declines, MA); Raney 1940a (breeding).

Golden Shiner

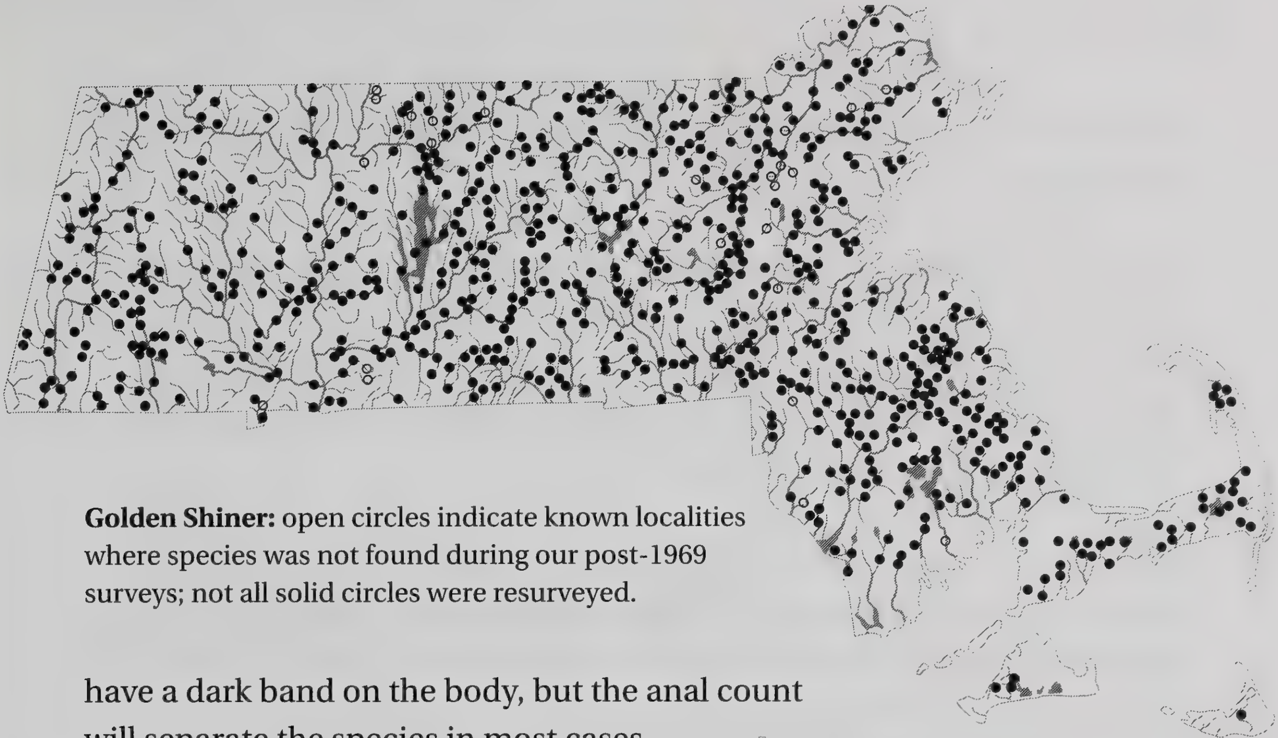
Native

Notemigonus crysoleucas (Mitchill 1814)

PLATE 9



IDENTIFICATION. Golden Shiners are deep-bodied, compressed fish with a down-curved lateral line. Among North American minnows, it is unique in having a fleshy, scaleless area on the ventral midline between the pelvic fins and the anus. This characteristic is often difficult to see in small specimens. The species can also be confirmed by the long anal fin, which usually has over 12 rays. Adults are brassy with orange fins. The Golden Shiner is similar to the introduced Rudd, which lacks the fleshy keel and has larger scales, fewer gill rakers, and two rows of pharyngeal teeth. Juveniles might be confused with other minnows because they are not deep-bodied and



Golden Shiner: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

have a dark band on the body, but the anal count will separate the species in most cases.

SELECTED COUNTS. D 7–9; A 10–15; Scales 9–12/41–50/3–4; GR 18–22; PT 0,5–5,0.

SIZE. This minnow commonly reaches 8 or 9 inches TL, but specimens close to 12 inches TL have been reported.

NATURAL HISTORY. Golden Shiners are found in a wide range of habitats, including lakes, ponds, and slow-moving rivers and streams. They spawn in spring and summer, from May to August. Spawning begins when the water temperature is around 70°F. The adhesive eggs are broadcast over submerged vegetation in shallow water, and the adults do not guard or otherwise tend the eggs. The young grow fast during their first summer and may reach 2 to 3 inches by fall. Most Golden Shiners do not spawn until their third summer and carry up to 200,000 eggs. Golden Shiners are midwater and surface feeders, often picking individual small prey out of the water column. They feed mainly on zooplankton, but adults sometimes feed on insects and small fishes. Algae are also an important part of their diet.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Golden Shiners are abundant and widely distributed. This species occurs in every drainage in the state, and its distribution has been enhanced by the release of fishes from bait-buckets. While the largest specimens are found in slow back-

waters of rivers and large ponds, small juveniles are often found in smaller hill streams.

NOTES. Golden Shiners, sometimes called "pond shiners," are an important forage species for game fishes. They are the most common bait fish sold in Massachusetts, and many are imported into the state from areas where they are commercially propagated. The Golden Shiner is known to hybridize with the introduced Rudd.

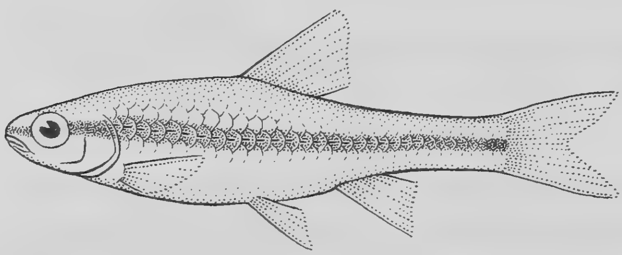
REFERENCES. Keast and Webb 1966 (feeding ecology); Scott and Crossman 1973 (biology, variations, Canada); Burkhead and Williams 1991 (hybrids, identification); Smith 1985, Jenkins and Burkhead 1993 (general).

Bridle Shiner

Native, State Special Concern

Notropis bifrenatus (Cope 1869)

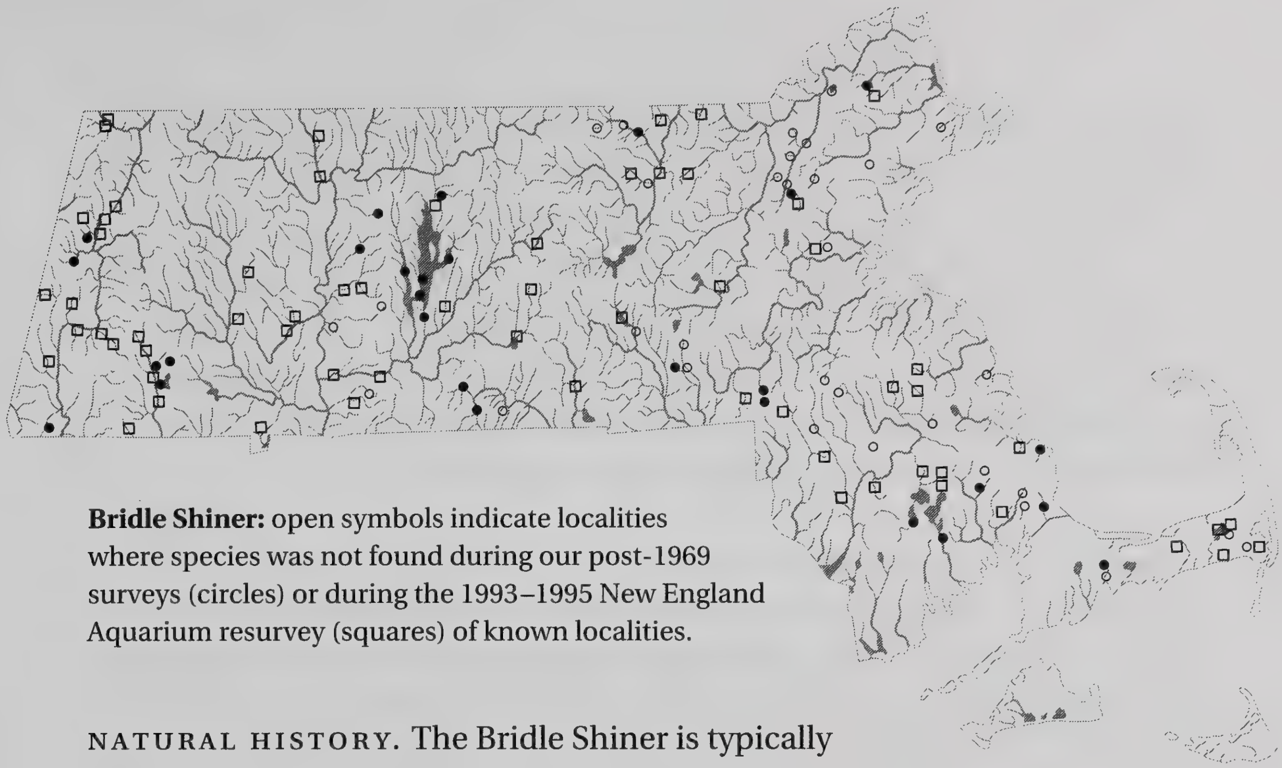
PLATE 20



IDENTIFICATION. Bridle Shiners are small minnows with a distinct dark lateral band that runs forward through the eye and around the snout; a small mouth; seven anal rays; and an incomplete lateral line. The young of other minnow species and young chubsuckers sometimes show a dark lateral band(s) but do not have the Bridle Shiner's large, outlined scales on the lateral body. These scale outlines are noticeable in specimens less than 1 inch TL (22 mm SL). Adults are straw-colored, and breeding males develop an intense yellow wash along the sides.

SELECTED COUNTS. D 8; A 7; Scales 4–5/32–36/4; PT 0,4–4,0.

SIZE. This is a small minnow, usually under 2 inches TL. The largest specimen we have seen measured just over 2.25 inches TL (46 mm SL).



Bridle Shiner: open symbols indicate localities where species was not found during our post-1969 surveys (circles) or during the 1993–1995 New England Aquarium resurvey (squares) of known localities.

NATURAL HISTORY. The Bridle Shiner is typically found in well-vegetated, quiet waters where schools often swim in and out of vegetation along the edge of ponds. Breeding occurs from late May to mid-July, and sometimes into August. Males usually pursue the larger females just below the surface in areas of open water over submerged vegetation. Spawning always occurs near the surface. About 10 eggs are released at each mating, and they fall to the bottom. Spawning is repeated many times. In an aquarium, over 320 eggs were released in a two-hour period. Eggs hatch in two to three days at 75°F, and by six weeks, the young resemble the adults. Bridle Shiners feed almost exclusively on animal matter, including small aquatic insects, copepods, cladocerans, and ostracods. This species is short-lived; most adults die during their second year. Bridle Shiners are prey for many larger fishes, particularly pickerel and bass.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, we have examined Bridle Shiner specimens from all major river basins except the Islands. Jenkins and Zorach, in their 1970 distributional study, noted that the Bridle Shiner was excluded from the upper Connecticut River by the fall line at Turners Falls. We, however, have collected one specimen from Willow Brook, a tributary to South Athol Pond. This single Millers Drainage record is probably an introduction or due to stream capture with the nearby Quabbin watershed.

NOTE. Although Bridle Shiners were common at least until the early 1960s, this interesting little minnow is currently declining in eastern Massachu-

setts, where few specimens were collected in our surveys between 1975 and 1989. A New England Aquarium survey (1993–1995) of many known localities found the Bridle Shiner at only 23 percent of its former sites in eastern Massachusetts. This shiner has a relatively small range, from southern New England to South Carolina, and it has been extirpated or is declining in much of the region. The Bridle Shiner is listed as a Species of Special Concern in Massachusetts. Recently it has been suggested that the Bridle Shiner belongs in the genus *Hybopsis* and not *Notropis.*

REFERENCES. Burkhead and Jenkins 1991, Whittier et al. 1997, Sabo 2000 (declines); Harrington 1947a (development), 1947b (breeding), 1948a (life cycle), 1948b (food), 1951 (spawning); Jenkins and Zorach 1970 (zoogeography and morphology), Mayden 1989 (placement in *Hybopsis*).

Spottail Shiner

Native

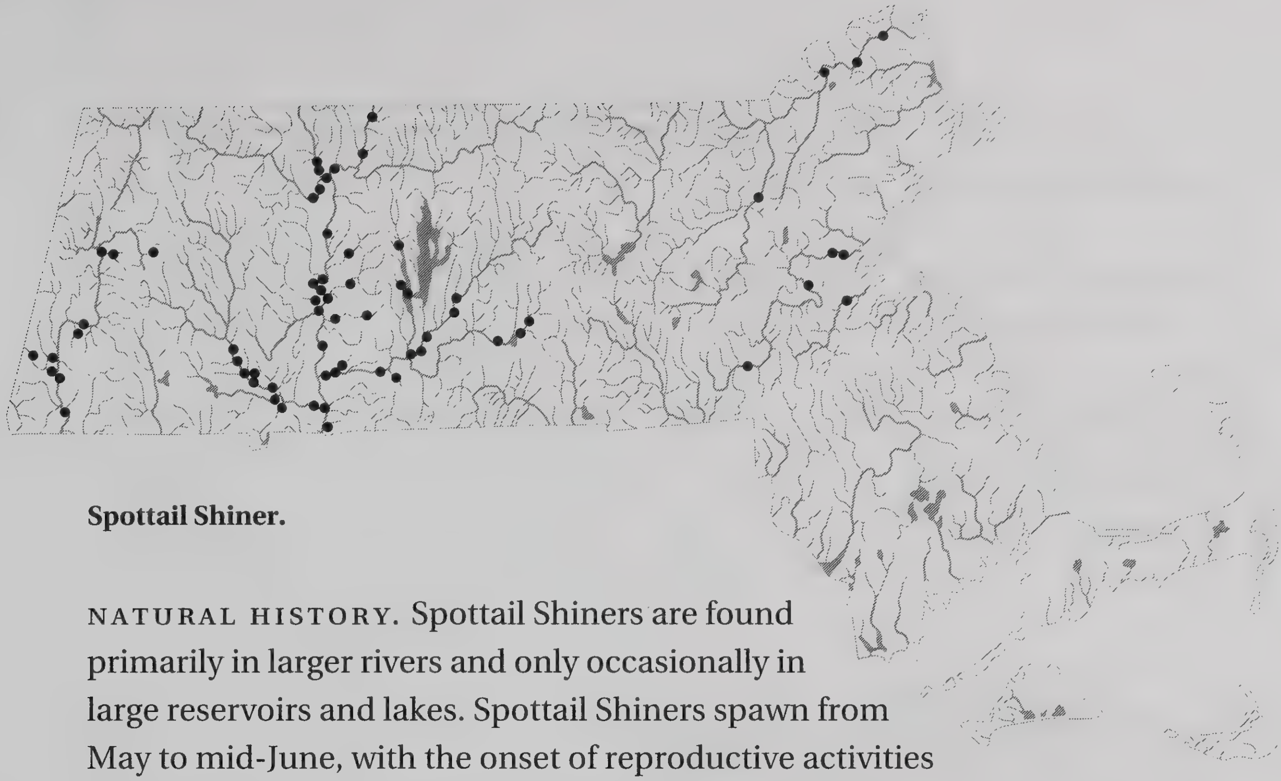
Notropis hudsonius Clinton 1824

PLATE 15

IDENTIFICATION. Spottail Shiners are medium-sized silvery minnows that usually lack obvious pigment patterns except for a diffuse midlateral stripe and a spot at the base of the caudal peduncle. This spot is often obscured in larger specimens. The mouth is slightly subterminal, median fins are often falcate, and the anterior lateral line scales are as wide as they are deep (see key Figure 17b).

SELECTED COUNTS. D 8; A 7–8; Scales 5/36–43/4–5; PT variable 0,4–4,0 to 2,4–4,2.

SIZE. Adults are normally about 4 inches TL; however, a few specimens over 5 inches TL (110 mm SL) have been found in Massachusetts.



Spottail Shiner.

NATURAL HISTORY. Spottail Shiners are found primarily in larger rivers and only occasionally in large reservoirs and lakes. Spottail Shiners spawn from May to mid-June, with the onset of reproductive activities apparently tied to water temperature. Although their spawning behavior has not been extensively studied, Spottail Shiners form large aggregations and scatter their eggs on sandy bottoms at the mouths of streams. Large females contain up to 2,700 eggs but, as in many other fishes, fecundity is related to size. The young grow fast and often reach 2 to 3 inches TL by the end of their first year. Growth slows after the first year, and it usually takes another two years for individuals to reach 4 inches TL. The species may live five years. Spottail Shiners tend to feed near the bottom and consume small mollusks, mayflies, and other aquatic or terrestrial insects. Adults also feed on large numbers of fish eggs, including their own.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, this minnow is abundant in the Connecticut, Deerfield, Chicopee, and Westfield drainages. It is common in the Merrimack and Housatonic river drainages, and a few specimens have been collected from the Neponset, Nashua, and Concord rivers. During the late 1970s, Spottail Shiners were common in the lower Charles River in Cambridge and Boston, but we have taken only a few specimens since 1985. Steven Shapiro (1976), who studied the species, thought that the Massachusetts populations outside of the Connecticut Basin most likely resulted from bait fish introductions. This may be true since they are absent from the Blackstone and Taunton river drainages, where this species might be expected to occur, and Spottail Shiners were not mentioned by early authors such as Storer, Putnam, and Goode and Bean.

NOTES. Over most of their range, Spottail Shiners are considered an important forage and bait minnow.

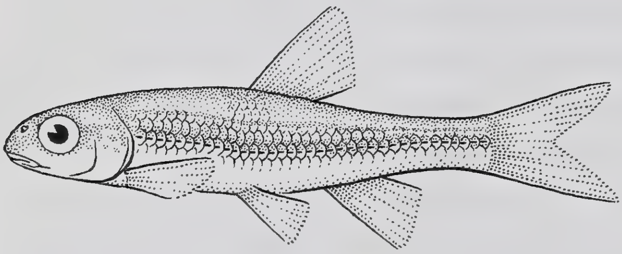
REFERENCES. Shapiro 1975 (bibliography), 1976 (age and growth, diet); Wells and House 1974 (life history).

Mimic Shiner

Introduced

Notropis volucellus (Cope 1865)

PLATE 16

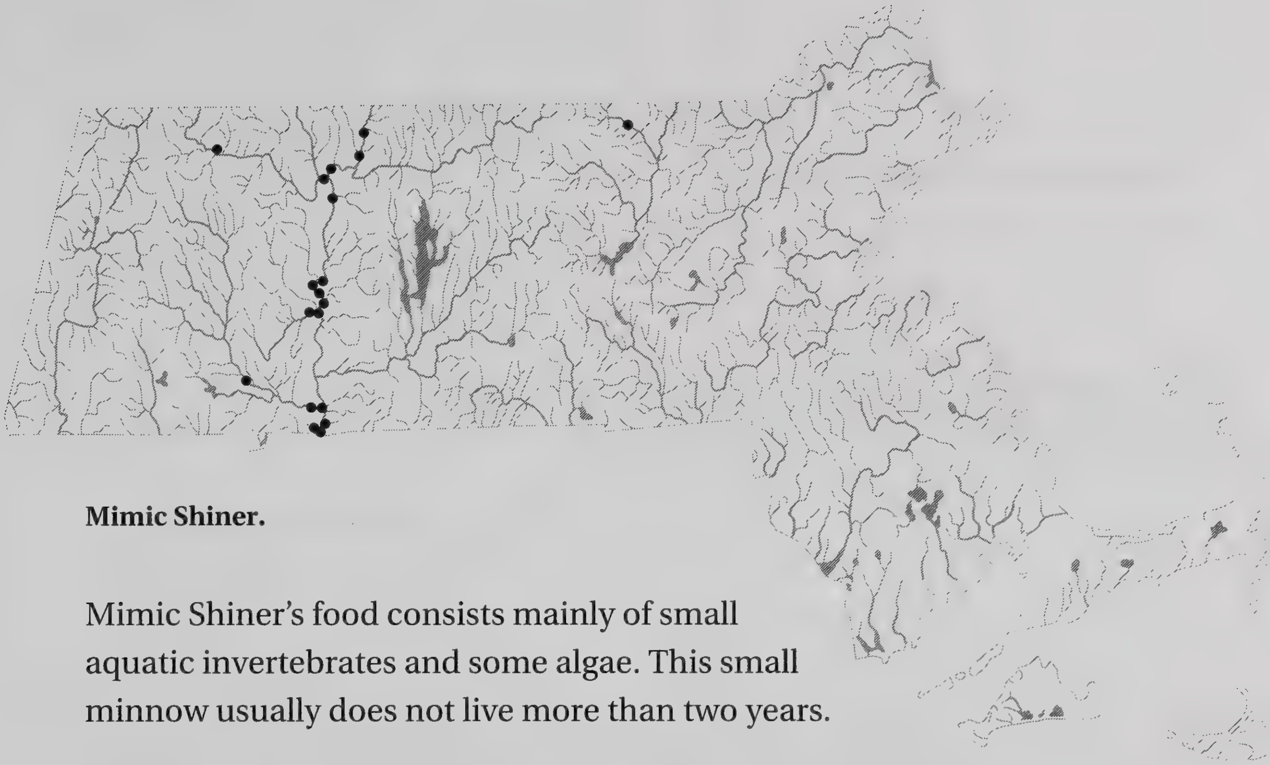


IDENTIFICATION. Mimic Shiners are a large-eyed, silvery minnow best identified by examining scales and pigment. Anterior lateral-line scales are deeper than they are wide (see key Figure 17a), lightly outlined, and large (fewer than 15 predorsal scales and fewer than five scale rows above the lateral line). A V-shaped pigment spot behind the anus, in combination with some pigment along the base of the anal fin, is also characteristic. In addition, a spot at the caudal base is expanded into a diffuse oval with a small forward-facing triangle at the base of the middle caudal rays.

SELECTED COUNTS. D 8; A 8; Scales 4/33–38/3–4; PT 0,4–4,0.

SIZE. Mimic Shiners seldom grow larger than 3 inches; however, we have collected a 4-inch TL (96 mm SL) specimen from Massachusetts.

NATURAL HISTORY. Within their native range, Mimic Shiners inhabit clear streams, smaller rivers, and lakes. In Massachusetts, they are primarily found in the main channel and quiet backwaters of large rivers. Almost nothing is known about this introduced minnow in Massachusetts, and only a few studies have been conducted in its native range. This species apparently spawns in the summer (June–July) and possibly at night. Eggs are deposited over aquatic vegetation and are not cared for by the adults. The



Mimic Shiner.

Mimic Shiner's food consists mainly of small aquatic invertebrates and some algae. This small minnow usually does not live more than two years.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Mimic Shiners were first found in a small tributary of the Connecticut River near Longmeadow by B. McCabe in 1941. Their introduction into Massachusetts waters probably resulted from bait fish releases before that date. Today, they are common in some areas of the Connecticut main stem and in the lower Westfield and Deerfield rivers. A small series of juveniles, collected by Prof. T.J. Andrews in 1953 from Townsend Harbor on the Squannacook River, is the only known record outside the Connecticut Basin.

NOTES. This shiner is native to a wide area west of the Appalachian Mountains and the Saint Lawrence Drainage. A small Atlantic slope population in North Carolina and Virginia is thought to be native.

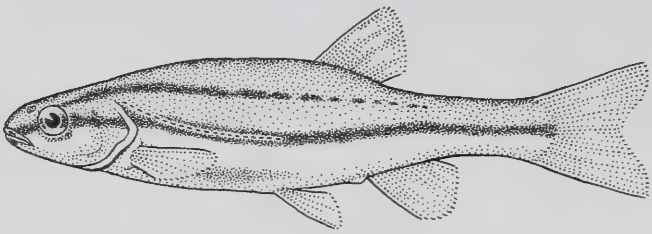
REFERENCES. Black 1945 (life history); Olmsted et al. 1979 (feeding); Scott and Crossman 1973 (Canada); Smith 1985, Jenkins and Burkhead 1993 (general).

Northern Redbelly Dace

Native, State Endangered

Phoxinus eos (Cope 1862)

PLATE 12

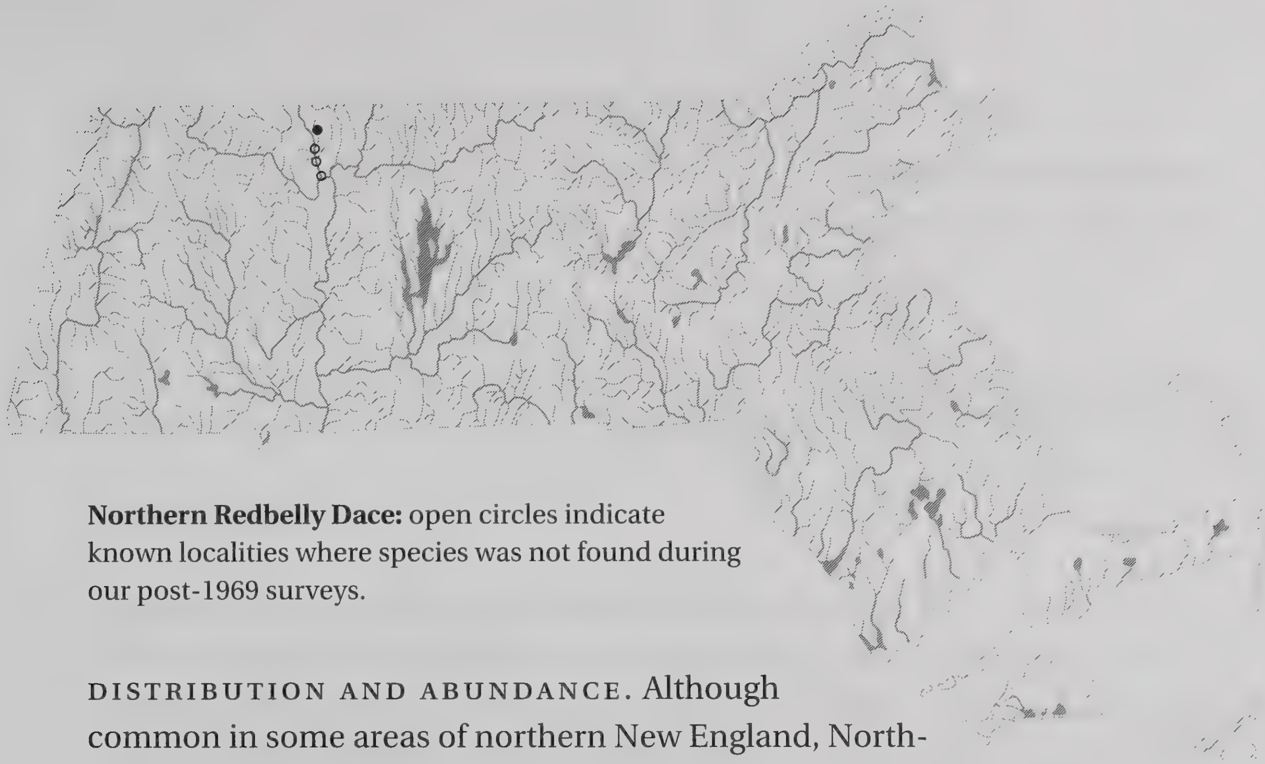


IDENTIFICATION. Northern Redbelly Dace have two horizontal dark or dusky stripes along their upper sides, small scales, a long, coiled intestine, and a black lining of the body cavity. The upper band is often broken into small dots or patches behind the dorsal fin, but the lower midlateral band is always complete. The flanks, belly, and throat range from creamy white in immatures to yellow or red in breeding adults.

SELECTED COUNTS. D 7–8; A 7–8; Scales 70–90; PT 0,5–5,0.

SIZE. This is a small minnow; most adults are only about 2 inches TL.

NATURAL HISTORY. Little is known about the Massachusetts population of this species. However, studies done elsewhere indicate that Northern Redbelly Dace breed in early spring to midsummer and that they may spawn two times each season. When spawning, a female, accompanied by one or more males, darts into a clump of filamentous algae, where 5 to 30 nonadhesive eggs are released and fertilized. Male Northern Redbelly Dace have comblike, tuberculate scales in front of their pectoral fins that may be related to reproductive activity. Eggs hatch in 8 to 10 days at 70° to 80°F, and the young may not reach maturity until their second or third summer. When found with Finescale Dace, *Phoxinus neogaeus,* the Northern Redbelly Dace reproduces in an interesting mosaic of diploid and triploid hybrids. Northern Redbelly Dace are long-lived for such small fishes; a Canadian study showed that some individuals live up to eight years. Like many herbivorous animals, Northern Redbelly Dace have long, coiled intestines. These dace feed mainly on plant material, primarily diatoms and filamentous algae, but also eat zooplankton and insects.



Northern Redbelly Dace: open circles indicate known localities where species was not found during our post-1969 surveys.

DISTRIBUTION AND ABUNDANCE. Although common in some areas of northern New England, Northern Redbelly Dace are rare in Massachusetts. They are known only from a small portion of the Green River system (Deerfield Drainage) in the vicinity of Greenfield. The Massachusetts population is historically known from only four localities in the Green River. B. McCabe first discovered this species in Massachusetts near downtown Greenfield in 1940, but it is no longer found at this site. In fact, these dace have been found only in a single small tributary since 1978, where they are uncommon. Changing land-use patterns and development, resulting in changes in water quality, could easily extirpate this disjunct population.

NOTES. Over most of its range, Northern Redbelly Dace are found in boggy, acidic environments, but in Massachusetts they inhabit a nonboggy clear stream and associated spring-fed seepage pools. The Massachusetts population is geographically isolated from the nearest New England population in the Sugar River system in the Connecticut Basin in New Hampshire. This species had been treated as a member of the genus *Chrosomus,* but recently it has been documented that it should be placed in the genus *Phoxinus.* This change reflects a close relationship between the six North American species and their Eurasian relatives.

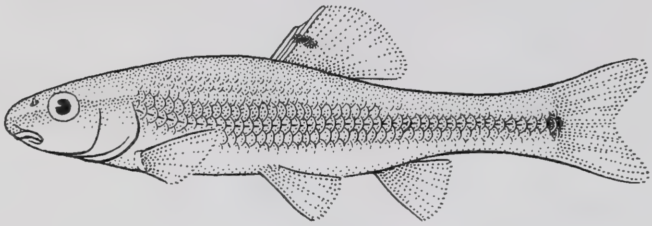
REFERENCES. Cochran et al. 1988 (diet); Bailey and Oliver 1939 (NH population); Howes 1985 (systematics and anatomy); McCabe 1942 (first MA records); Scott and Crossman 1973 (review, Canada); Goddard et al. 1989, Goddard and Schultz 1993 (hybrids).

Bluntnose Minnow

Introduced

Pimephales notatus (Rafinesque 1820)

PLATE 23

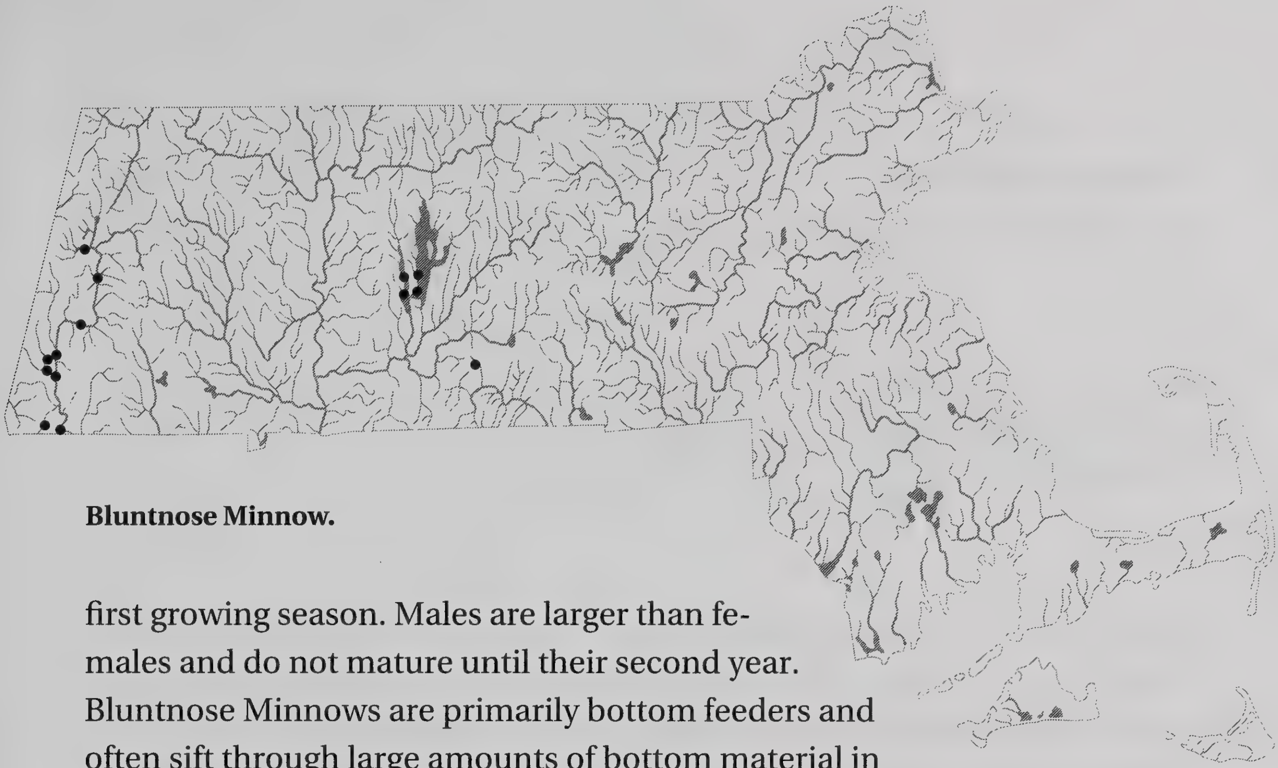


IDENTIFICATION. Bluntnose Minnows are most similar to Fathead Minnows, which also have a well-developed but short first dorsal ray that is separated from the first principal ray (in adults) (see key Figure 8a) and small, irregular, crowded scales from the nape to the dorsal fin. Its body is quite round, almost square in cross section, and is elongate with a complete lateral line, a cross-hatched scale pattern, and a well-marked spot at the base of the caudal fin. This species has a blunt head with a slightly subterminal mouth. It has a coiled intestine, a dark peritoneum, and a dark band along the snout and body. Males become dark, almost black, during the breeding season.

SELECTED COUNTS. D 8; A 7; Scales 6/42–50/4; PT 0,4–4,0.

SIZE. Adult Bluntnose Minnows typically range from 3 to 4 inches TL.

NATURAL HISTORY. Bluntnose Minnows are found in a wide variety of habitats but usually prefer sandy to gravelly substrates. Spawning lasts from spring to midsummer. Males excavate a pocket under flat stones, wood, or cans to make a nest. Males vigorously guard the nest during the spawning season and chase away rival males and all other species of fishes. After a female enters a nest, she deposits a number of adhesive eggs on the undersurface of the roof. Eggs are added to the nest by a number of females; up to 2,500 eggs have been found in a single nest. Spawning is prolonged and different-aged eggs may be found in the same nest. Males also clean the eggs, remove dead or diseased eggs, and circulate water in the nest. If the male is removed from the nest, the eggs will not hatch. Eggs hatch in 10 to 14 days, and the young reach almost 2 inches TL at the end of their



Bluntnose Minnow.

first growing season. Males are larger than females and do not mature until their second year. Bluntnose Minnows are primarily bottom feeders and often sift through large amounts of bottom material in search of a variety of invertebrates.

DISTRIBUTION AND ABUNDANCE. Bluntnose Minnows are not native to Massachusetts, and the species was not found here until our 1979 survey of the Housatonic River. B. McCabe's 1940 surveys did not find the species. It is presumably a recent introduction resulting from bait-bucket releases. The species appears to be common and established in the Housatonic, where it is now known from over 10 sites. This species was also first noticed in Quabbin Reservoir when the MDFW collected a single juvenile from the east shore in the early 1980s. Our 1989 shoreline samples of Quabbin show that it is now the most common minnow in the area of the reservoir that we surveyed. Bluntnose Minnows are also known from Little Alum Pond, Brimfield.

NOTES. Bluntnose Minnows are important forage fish throughout their native range. They are widely used as bait fish, but generally do not tolerate crowded bait-buckets. When they are propagated in ponds with artificial nest sites, up to 250 pounds per acre have been produced.

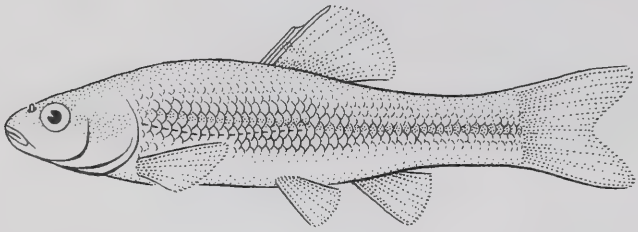
REFERENCES. Becker 1983, Scott and Crossmann 1973 (biology); Keast and Webb 1966 (feeding); Hubbs and Cooper 1936 (behavior); Dobie et al. 1956 (propagation).

Fathead Minnow

Introduced

Pimephales promelas Rafinesque 1820

PLATE 24

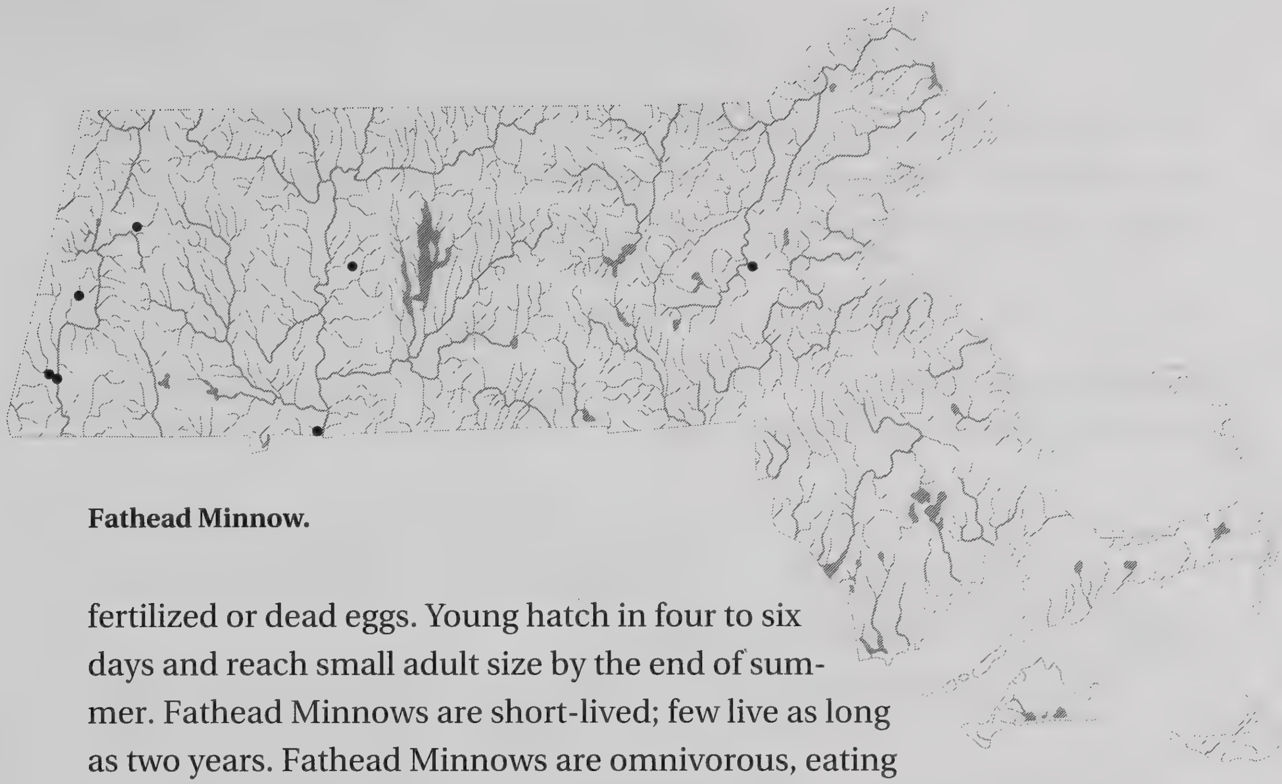


IDENTIFICATION. Similar to Bluntnose Minnows, Fathead Minnows also have the well-developed but short first dorsal ray separated from the first principal ray (in adults) (see key Figure 8a) and small, irregular, crowded scales from the nape to the dorsal fin. Fathead Minnows have a chunkier body, and a terminal rather than slightly subterminal mouth; they lack the crosshatched scale outlines and the prominent basicaudal spot of Bluntnose Minnows. They have a dark peritoneum and a coiled gut. A red-orange form is marketed in pet and bait stores as an "orange tuffy."

SELECTED COUNTS. D 8; A 7; Scales 9/41–54/9; PT 0,4–4,0.

SIZE. The Fathead Minnow generally reaches 4 inches TL, but most of the Massachusetts specimens that we have examined are one-half that size.

NATURAL HISTORY. Fathead Minnows are spring and summer spawners, beginning when water temperatures are above 59°F. Like Bluntnose Minnows, Fathead Minnows deposit their eggs on the underside of underwater objects. When necessary, the males excavate a cavity under the object to create a nest, using their snouts and tails. The underside of the nest is cleaned, and finally rubbed with a dorsal pad that contains mucous cells. The exact function of the mucous is unknown, but it may assist in egg attachment or chemical location of the nest, or it may prevent fungus and increase egg survival. Spawning is nocturnal, and a female may deposit 100 to 300 eggs in the nest at a time, after which she is chased away. The adhesive eggs stick to the roof of the nest or to other eggs. Up to 13,000 eggs in different stages of growth have been found in a single nest. Males actively guard the nest and tend the eggs by cleaning, circulating water, and removing un-



Fathead Minnow.

fertilized or dead eggs. Young hatch in four to six days and reach small adult size by the end of summer. Fathead Minnows are short-lived; few live as long as two years. Fathead Minnows are omnivorous, eating plant material, particularly algae and detritus, and smaller invertebrates. The proportion of each type of food varies with the season, the age of the fish, and the locality.

DISTRIBUTION AND ABUNDANCE. The Fathead Minnow is native to much of North America west of the Hudson Drainage. It is not native to Massachusetts. The species was first recorded from Massachusetts by P. Mugford in 1969. We did not find confirming specimens until 1979, when a population was found at the junction of the Green and Housatonic rivers in Great Barrington. They are common where they are found in the Housatonic but known from only a few sites. Reproducing populations were found in the Concord Drainage and in a pond on the University of Massachusetts' Amherst campus during the late 1980s. A single adult was also collected from a small tributary to the Connecticut River, Agawam, in 1980. These Massachusetts records are probably the result of bait-bucket releases.

NOTES. Fathead Minnows are hardy and can endure relatively low oxygen levels, high levels of pollutants, and a wide spectrum of pH levels. They are intensively propagated and widely used as a bioassay organism, are an excellent forage fish, and are a popular bait fish in the Midwest. Unlike the Bluntnose Minnow, the Fathead Minnow can survive crowded bait-buckets for many hours. It has been propagated in great quantity, even in tertiary sewage treatment ponds. Under these conditions, 100 pounds of stocked Fathead Minnows have produced up to 7,200 pounds in three months.

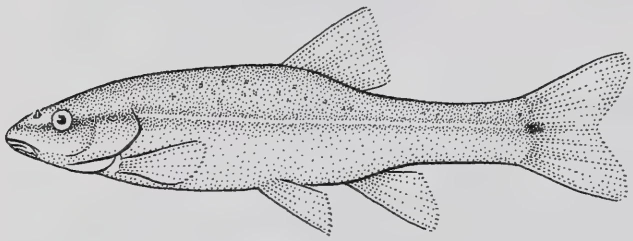
REFERENCES. Becker 1983 (general); Smith and Murphy 1974 (dorsal pad); Andrews and Flickinger 1974 (spawning); Dobie et al. 1956 (propagation); Mugford 1969 (Massachusetts record).

Blacknose Dace

Native

Rhinichthys atratulus (Hermann 1804)

PLATE 21

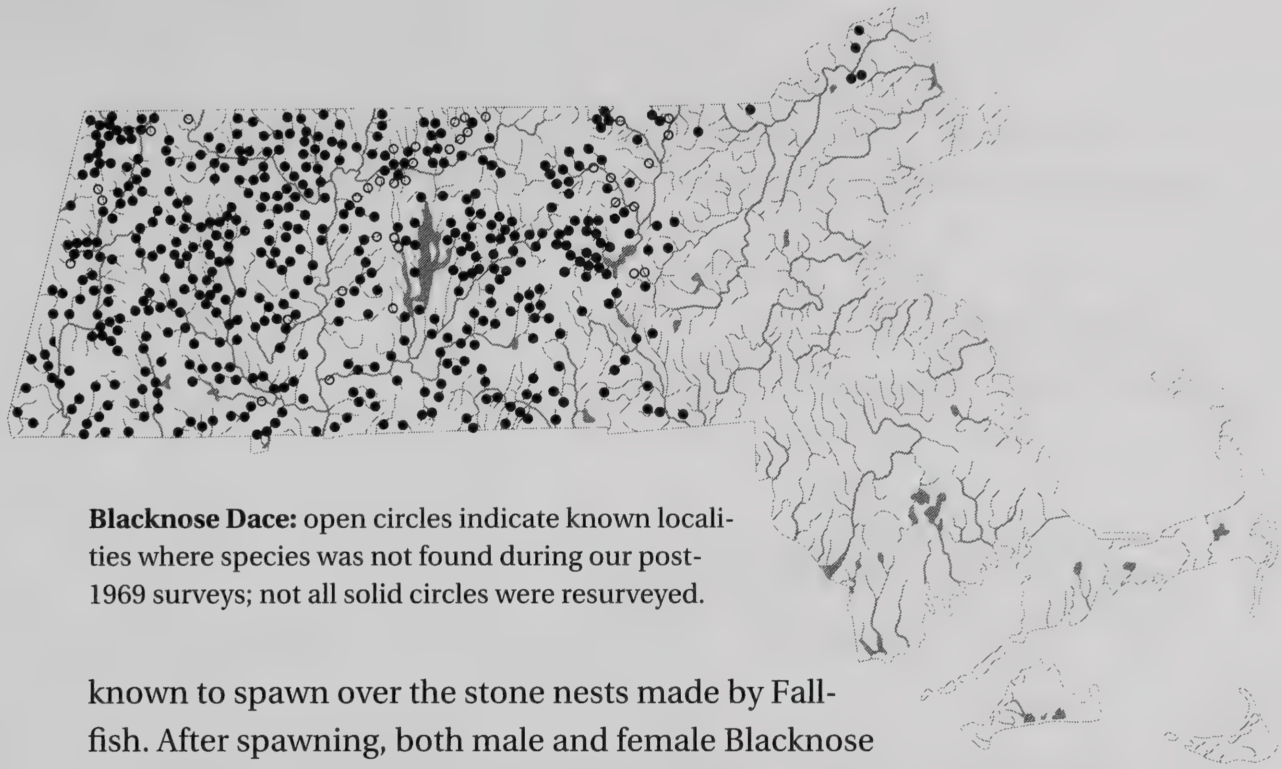


IDENTIFICATION. Blacknose Dace have a barbel at each corner of the mouth, and a band of tissue (frenum) connects the upper lip to the snout. They are most similar to the Longnose Dace but can be distinguished by the relative length of the snout, the eye size, the position of the eye in relation to the mouth (see key Figure 13b), and the pigment stripe on the snout. A dark stripe running around the snout, through the eyes, and along most of the midbody separates the olive-brown back and a silvery-white belly. In breeding males, the pectoral, pelvic, and anal fins are orange.

SELECTED COUNTS. D 8; A 7; Scales 10–12/52–60/7–9; PT 2,4–4,2.

SIZE. Blacknose Dace are small, usually only reaching 3 inches TL. The largest one that we have examined is about 4 inches TL (87 mm SL).

NATURAL HISTORY. Blacknose Dace can be found in almost every hill stream in central and western Massachusetts. When disturbed, Blacknose Dace quickly disappear under rocks, boulders, or logs, only to return in a few minutes. Blacknose Dace begin spawning in early June when they leave the deeper pools and gather in and around riffles. Males guard a small territory, and there is constant chasing. Several males may chase a single female, and if ready to spawn, the female slides up beside one of the males. The spawning act lasts one or two seconds; eggs and milt are simply broadcast into the water column. Nests are never built; however, Blacknose Dace are



Blacknose Dace: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

known to spawn over the stone nests made by Fallfish. After spawning, both male and female Blacknose Dace settle on the bottom to rest momentarily and then quickly resume spawning with the same or different partners. Females contain an average of 750 small eggs (0.03 inches in diameter), and fry are less than 0.25 inches long when they hatch. Blacknose Dace feed on a wide variety of aquatic invertebrates and terrestrial insects. Aquatic fly larvae are a favored prey. Blacknose Dace may live for three to possibly four years.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Blacknose Dace are by far the most common stream minnow, occurring from the Hudson to the Blackstone drainages and north through western portions of the Merrimack River Drainage. In the eastern portion of the state, Blacknose Dace are now found only in five streams tributary to the Merrimack River, and in four streams in the Concord-Assabet River Drainage. Blacknose Dace are notably absent from all other Massachusetts coastal drainages.

NOTES. A number of Massachusetts fishes are sometimes infested with black spot disease, which is often indicative of stressed habitats. This disease is common in Blacknose Dace; individuals are sometimes almost entirely covered with the diagnostic small black spots, especially when they are trapped in pools as water recedes. The spots, which can be found on the body or the fins, are the cysts of a trematode parasite, *Neascus* sp. These parasites are passed from bird droppings, to snails, to fishes, and back to birds, such as the Belted Kingfisher, that prey on fishes.

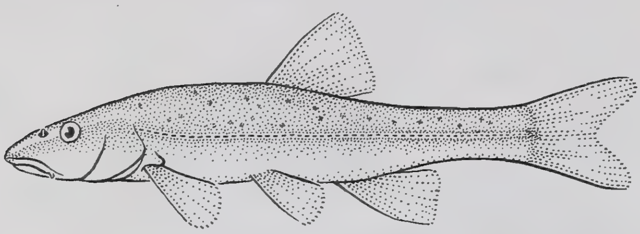
REFERENCES. Houde 1964 (black spot, MA); Raney 1940b (breeding); Reed and Moulton 1973 (age and growth, MA); Traver 1929 (life history).

Longnose Dace

Native

Rhinichthys cataractae (Valenciennes 1842)

PLATE 22

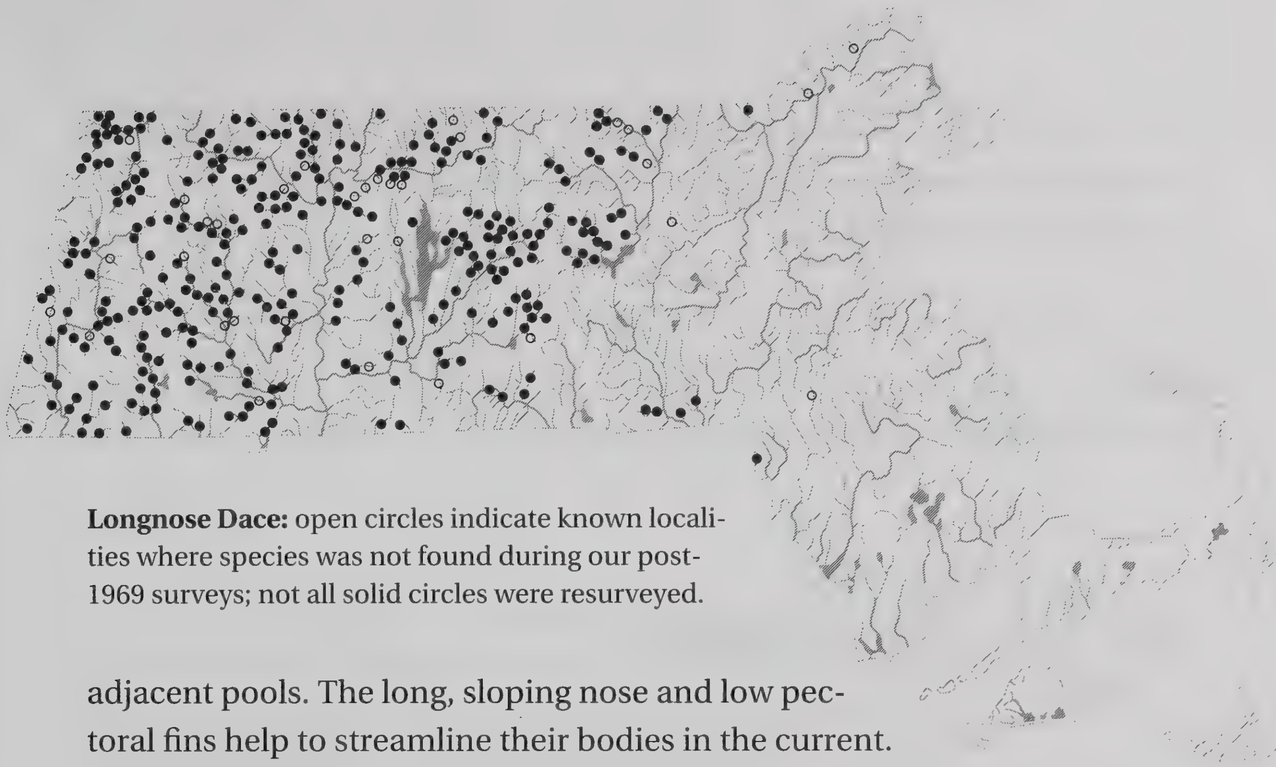


IDENTIFICATION. Longnose Dace have a barbel at each corner of the mouth, and a band of tissue (frenum) connects the upper lip to the snout. They are similar to Blacknose Dace but have a subterminal mouth and usually lack the dark band around the snout and along the body. They can be positively identified by the length of the snout, eye size, and the position of the eye in relation to the mouth (see key Figure 13b). The stripes on the snout and the midlateral area are diffuse and are not prominent. Breeding males are orange-red at the base of the pectoral and pelvic fins, on the cheek, throat, and lips; an orange wash is sometimes present on the midlateral area and on the dorsal and anal fins. Longnose Dace lack papillae found on the lips of suckers.

SELECTED COUNTS. D 8; A 7; Scales 11–13/61–75/8; PT 2,4–4,2.

SIZE. Adults are normally about 3 inches TL. The largest Massachusetts specimen recorded is from the Westfield River and is close to 6 inches TL (139 mm SL).

NATURAL HISTORY. Longnose Dace are usually associated with steep gradient, cold-water streams, but they are sometimes found in lower-gradient, warm-water rivers. They are sometimes abundant, appearing in densities of almost one fish per square foot. Longnose Dace can live to five years and spend most of their adult lives on or near the bottom in turbulent water or



Longnose Dace: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

adjacent pools. The long, sloping nose and low pectoral fins help to streamline their bodies in the current. Spawning, which starts in the spring, probably extends into early summer. Although they do not build nests, each male guards a territory about 10 inches in diameter. After spawning, eggs hatch in three to four days at 70°F. Unlike the adults, the young live off the bottom during the early part of their lives. Their diet consists primarily of immature aquatic insects that cling to rocks and boulders. Longnose Dace are one of the chief predators of larval blackflies and midges, but they will also prey on other small aquatic invertebrates.

DISTRIBUTION AND ABUNDANCE. In western Massachusetts, Longnose Dace are common in clear streams with riffles, boulders, and gravel, but have also been sampled in large numbers from lower-gradient, main stem rivers, including the Housatonic River, Stockbridge. Longnose Dace are absent from almost all of the eastern part of the state except in upland tributaries to the Nashua River. They are rare in the lower Merrimack Drainage, where there are only two records: one from Lawrence in 1859 and one from Andover in 1987. The Longnose Dace may have been more common along the Merrimack before industrial pollution and dams. With the exception of one undocumented fisheries record from the upper Taunton drainage, they are absent from all other Massachusetts coastal drainages.

NOTES. Longnose Dace were originally described from Niagara Falls and were given the appropriate specific name *cataractae.*

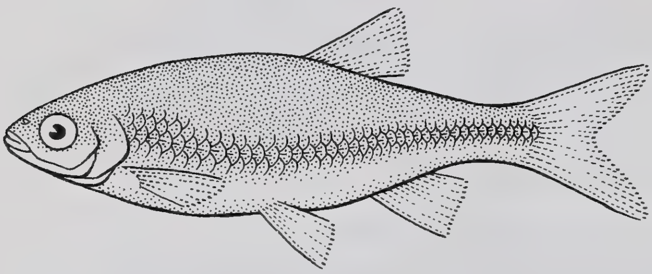
REFERENCES. Cooper 1980 (development); Reed 1959 (diet); Reed and Moulton 1973 (age and growth); Scott and Crossman 1973, Jenkins and Burkhead 1993 (general).

Rudd

Introduced

Scardinius erythrophthalmus (Linnaeus 1758)

PLATE 8

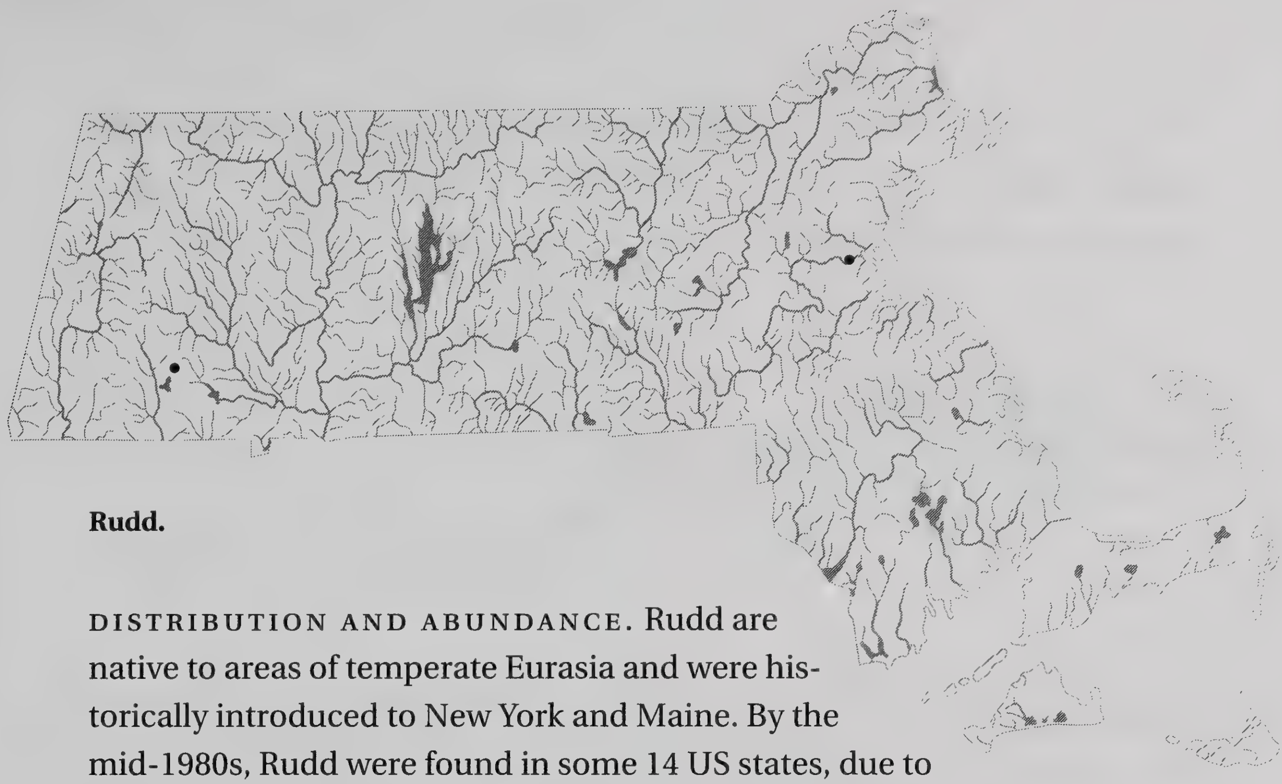


IDENTIFICATION. Rudd are deep-bodied, compressed fish with a down-curved lateral line. They closely resemble Golden Shiners, but Rudd lack the fleshy, scaleless area on the ventral midline between the pelvic fins and the anus. Adults are silvery with red fins. Golden Shiners also have smaller scales, more gill rakers, and only one row of pharyngeal teeth (see key Figure 4b).

SELECTED COUNTS. D 9–11; A 11–14; Scales 7–9/38–41/3–5; GR 10–13; PT 3,5–5,3.

SIZE. Rudd commonly grow to 10 or 12 inches TL but may reach 18 inches TL.

NATURAL HISTORY. Almost nothing is known about the natural history of the introduced Rudd in North America. In Eurasia, it inhabits lakes, ponds, and slow-flowing waters. Rudd spawn in the spring over submerged vegetation, usually between April and June. Adults do not mature until they are three to four years old or over 5 inches TL. They are principally midwater and surface fish, feeding mostly on insects, crustaceans, and filamentous algae. Rudd have been documented as hybridizing with the native Golden Shiner in North America.



Rudd.

DISTRIBUTION AND ABUNDANCE. Rudd are native to areas of temperate Eurasia and were historically introduced to New York and Maine. By the mid-1980s, Rudd were found in some 14 US states, due to bait fish releases. It is unknown if they are reproducing in all of these states. The Rudd was imported to Massachusetts as a bait minnow at least as early as the late 1980s and confirmed in the wild by our surveys of the Charles River in Cambridge in 1991, when two specimens were collected: an adult (206 mm SL) and a young (88 mm SL) found on different dates. The presence of both juveniles and adults over several years confirms reproduction in the lower Charles River. A record exists of the species from Benton Lake, Otis.

NOTES. Because this minnow was used for bait for a number of years before its importation was prohibited by MDFW in 1990, there is a good possibility that it will be found reproducing in other areas of the state.

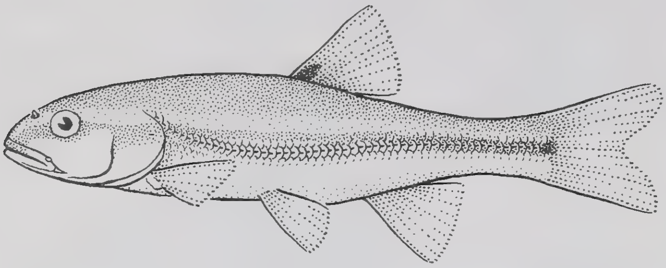
REFERENCES. Courtenay and Stauffer 1984 (US introductions); Burkhead and Williams 1991 (hybrids, identification); Hartel 1992 (Massachusetts records); Wheeler 1969 (biology).

Creek Chub

Native

Semotilus atromaculatus (Mitchill 1818)

PLATE 19

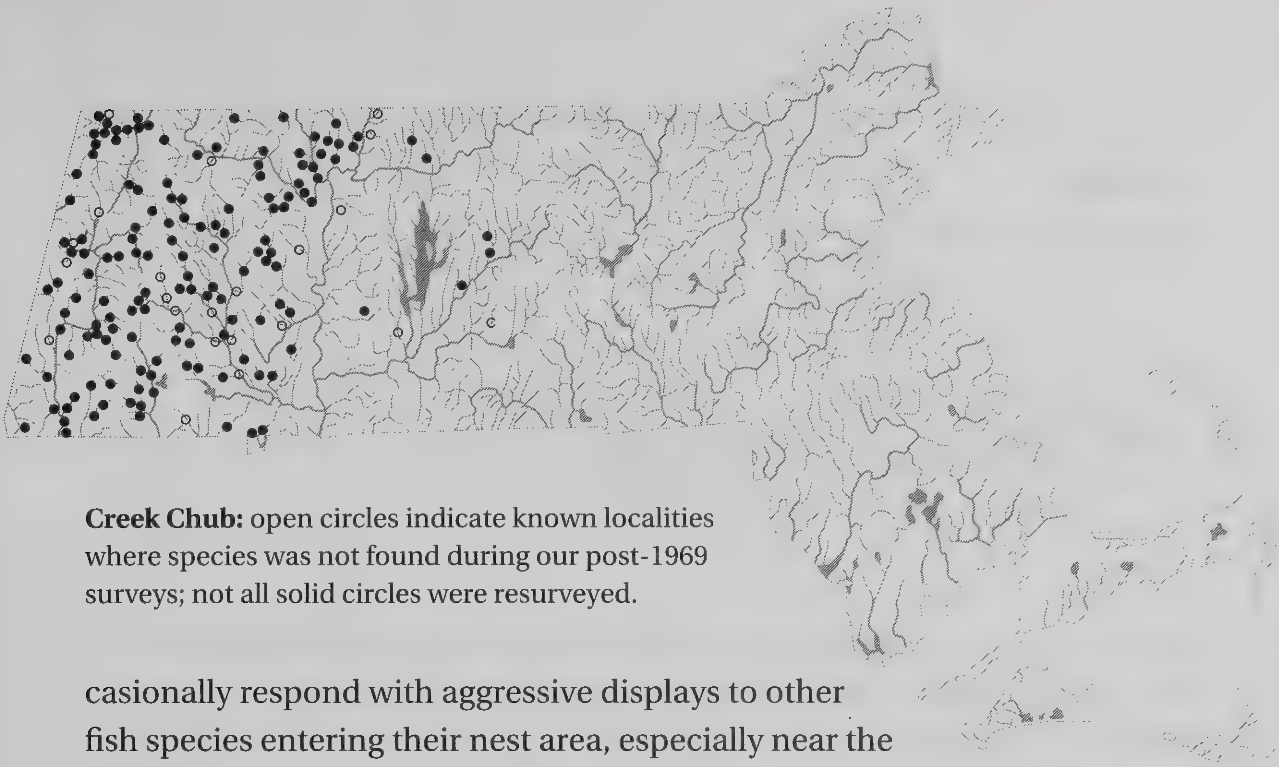


IDENTIFICATION. Creek Chub are similar to Fallfish, which also have a leaflike fleshy barbel in the groove behind the upper jaw (see key Figure 11b). Care must be taken in looking for the barbels; they may rarely be absent from either side or both sides. Creek Chub have a distinctive, small spot near the anterior base of the dorsal fin and more than 50 lateral line scales. Young Creek Chub have a lateral band from the snout to the caudal base that often ends in a basi-caudal spot. Breeding males darken dorsally and have a yellow to rosy wash laterally on the body.

SELECTED COUNTS. D 8; A 8; Scales 8/50–62/5; PT 2,5–4,2.

SIZE. Adult Massachusetts Creek Chub are usually 4 to 5 inches TL. The largest Massachusetts specimen that we have seen measured about 6.5 inches TL (136 mm SL). However, they are known to grow as large as 12 inches TL in other parts of their range.

NATURAL HISTORY. In Massachusetts, Creek Chub are most often found in small streams with gravel bottoms. Spawning takes place in the spring when water temperatures range from 54° to 61°F. Nest building has been described by Ross (1977a:36) as follows: "...male Creek Chubs move onto gravel runs" and the male "...forms a nest depression by carrying sand and gravel from the nest in his mouth. Once a depression is formed, the male removes gravel only from the downstream edge of the depression. This material is deposited on the upstream edge of the depression in the area where spawning occurs. Thus, eggs that are released in the nest are subsequently covered with a layer of gravel which is moved by the male." Creek Chub oc-



Creek Chub: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

casionally respond with aggressive displays to other fish species entering their nest area, especially near the time of spawning. However, they always respond to other male Creek Chub. Creek Chub are opportunistic, feeding at all depths in the stream, most intensively in the evening. Their diet includes a wide range of aquatic insect larvae and pupae, fishes, and mollusks. Burrowing bottom organisms are taken to a lesser extent because the Creek Chub seems to rely on sight to find food. By their third summer, Creek Chub average about 5 inches, and they probably live longer than four years.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Creek Chub are found in most major river drainages west of the Connecticut River. East of the Connecticut River, Creek Chub are much less common. Only four recent records exist from the Chicopee River Drainage and two records from the Millers River Drainage.

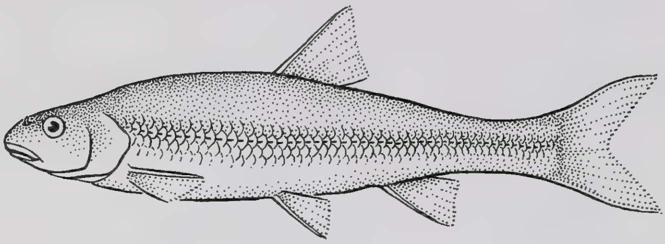
REFERENCES. Barber and Minckley 1971 (food); Dinsmore 1962 (life history); Johnston and Ramsey 1990 (relationships); Maurakis et al. 1990 (nests); Reighard 1910, Ross 1977a, 1977b (behavior).

Fallfish

Native

Semotilus corporalis (Mitchill 1817)

PLATE 18

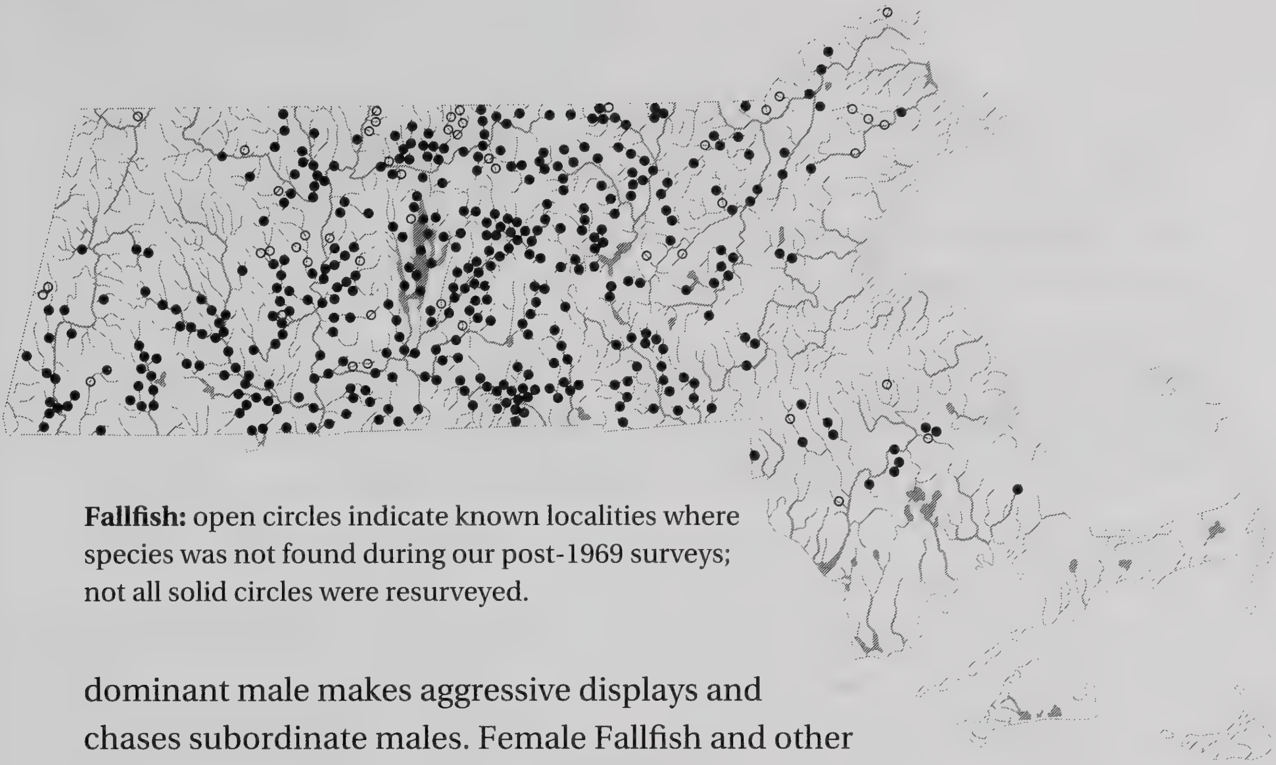


IDENTIFICATION. Fallfish are most similar to Creek Chub, which also have a leaflike, fleshy barbel in the groove behind the upper jaw (see key Figure 11b). The barbels have to be looked for carefully because they may be rarely absent from either or both sides. Opening the mouth and directing a small jet of air into the groove behind the posterior area of the maxilla will make the barbel easier to observe. Adult Fallfish have diagnostic dark marks at the base of each scale (see key Figure 14a) and fewer than 50 lateral-line scales. Fallfish are silvery with a dark olive-brown to almost black dorsal area. Young have a pronounced lateral band.

SELECTED COUNTS. D 8; A 8; Scales 7/43–50/5; PT usually 2,5–4,2

SIZE. This species is Massachusetts' largest native minnow. Adults just under 1 foot long are common. The largest recorded Massachusetts specimen, from Quabbin Reservoir, measured 19 inches (462 mm SL).

NATURAL HISTORY. In Massachusetts, Fallfish are most often found in rivers and steams with rock and gravel substrates, but some populations occur in larger ponds and reservoirs. Adults migrate to areas with rock and gravel substrate in the spring. Dominant males begin building nests in mid-April, when water temperatures are above 59°F. Males dig a pit, then pick up stones weighing up to 6 ounces in their mouths and drop them in the pit to form the nests. The nests may be as small as 1 foot to over 4 feet in diameter and almost 2 feet high. The shape of the nest depends on its location; nests built in current are often elongated downstream by the force of the water, while those in quiet water are dome shaped. Fallfish spawning involves a social hierarchy established by the behavior of the male. The



Fallfish: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

dominant male makes aggressive displays and chases subordinate males. Female Fallfish and other species are not chased. The visual cue of a male carrying stones and dropping them into the nest triggers the female to rush onto the nest to spawn. Spawning is often communal with varying numbers of both sexes involved. During communal spawning the fishes "...form a layered aggregation, all facing upstream and in close contact with each other...with the dominant male...always located centrally, next to the nest" (Ross and Reed, 1978:218). Fertilized eggs are adhesive, stick to the nest, and hatch in about six days. Fallfish are omnivorous, eating plankton until they are about 1.5 inches TL and gradually switching to larger foods, such as algae, insects, crayfish, and fishes. In a study in the Mill River, Amherst, Fallfish were found to eat more aquatic insects during the spring and gradually switched to heavy feeding on terrestrial insects by midsummer. It takes five years for a Fallfish to reach about 8 inches TL and almost 10 years to reach maximum size. Males become mature in their third spring and females in their fourth.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Fallfish are common in the Connecticut Basin but rare in the eastern part of the state. The latest Charles River records date back more than 30 years. Storer (1867) stated that they were found in many rivers; his 1839 description is based on a 14-inch specimen from Walpole (Charles River Drainage). Recent records of Fallfish from Cape Cod are lacking; however, two mounted specimens (12 and 16.5 inches TL) in the Springfield Museum of Natural History are labeled from "ponds on Cape Cod, 1911."

NOTES. Other fishes are attracted by the nest-building behavior of the Fallfish, and some actually spawn over their nests. In Massachusetts, Common Shiners and Blacknose Dace sometimes spawn in this manner and may gather around Fallfish nests by the hundreds.

REFERENCES. Johnston and Ramsey 1990 (relationships); Maurakis et al. 1990 (nests); Reed 1971 (growth, development, diet); Ross and Reed 1978 (reproduction); Ross 1983 (behavior); Smith 1985 (general).

Sucker Family

Catostomidae

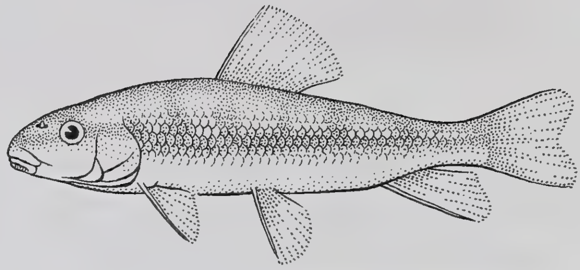
The suckers, with some 70 species, are closely related to the true minnows. Most suckers are endemic to North America, but two species, one in China and one in northeastern Siberia, are found in northeastern Asia. Most sucker species require relatively clean silt-free water, and at least 20 species are currently listed as threatened or rare in North America, in part due to habitat change. The Harelip Sucker, *Moxostoma lacerum,* was one of the first North American fishes to become extinct. It was formerly common from Ohio to Georgia and Arkansas, but none has been found since 1895. As the common name indicates, most members of this family have distinctive, subterminal, suckerlike mouths. The toothless lips are fleshy and can protrude into a short tube. Sucker lips are pleated with lines and bumps that contain tactile and other sensory organs. All suckers have comblike pharyngeal jaws with 20 or more teeth. The anal fin is set much farther back on the body than on most minnows.

Reproduction occurs in spring. During this time, the adults congregate in spawning areas, usually upstream from the deeper pools and channels where they normally live or in the shallows of lakes and reservoirs. Spawning occurs in groups of three, usually one female tightly flanked by two males. Fertilized eggs sink to the bottom and are buried by the movements of the anal and caudal fins of the adults, but nests are not built. During the spawning period, male suckers develop breeding tubercles, especially on their heads and anal fins. One specimen of a Northern Hog Sucker, *Hypentelium nigricans,* was found in a tributary to the Connecticut River, Hadley, in 1953, but this introduced species has not been found since.

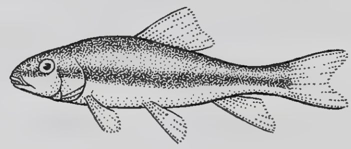
REFERENCES. Bruner 1991 (bibliography); Page and Johnson 1990 (spawning behavior); Williams et al. 1989, Miller et al. 1989 (rare and extinct species); Smith 1992, Fink and Fink 1996 (systematics and relationships); Jenkins and Burkhead 1993 (general).

Key to Massachusetts Suckers

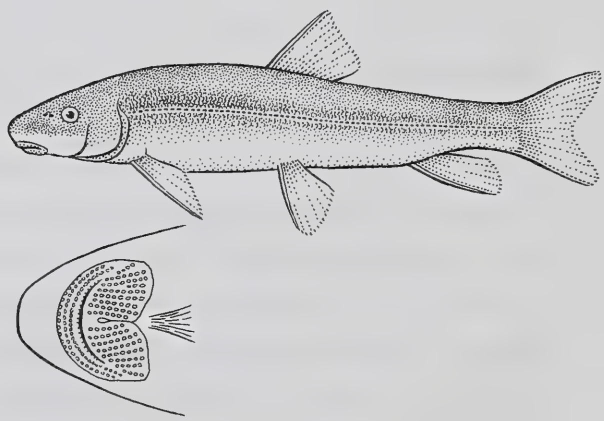
1a. Lateral line absent; scales large, less than 45 in midlateral series; young with dark dorso-lateral stripes. Creek Chubsucker, *Erimyzon oblongus,* page 141, Plate 25.



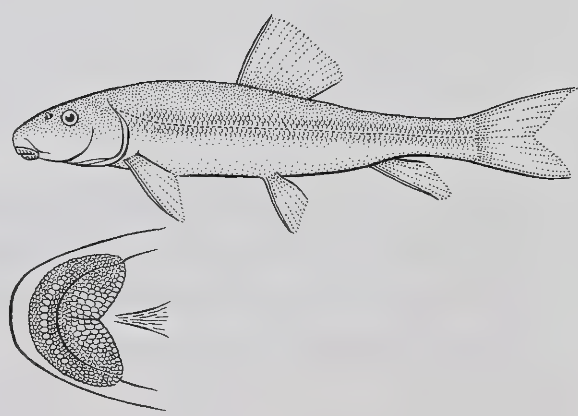
1b. Lateral line present; scales small, more than 55 lateral scales; young without dark horizontal stripes (not illustrated). Go to 2.



2a. Snout long, extending well ahead of the mouth; more than 85 scales in lateral series. Longnose Sucker, *Catostomus catostomus,* page 137, Plates 27, 28.



2b. Snout short, barely extending ahead of the mouth; scales fewer than 75 in lateral-line series. White Sucker, *Catostomus commersoni,* page 139, Plate 26, 28.

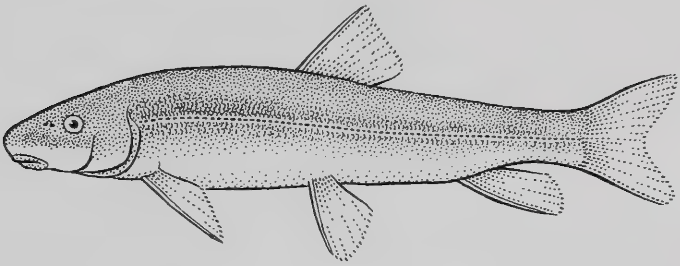


Longnose Sucker

Native, State Special Concern

Catostomus catostomus (Forster 1773)

PLATES 27, 28

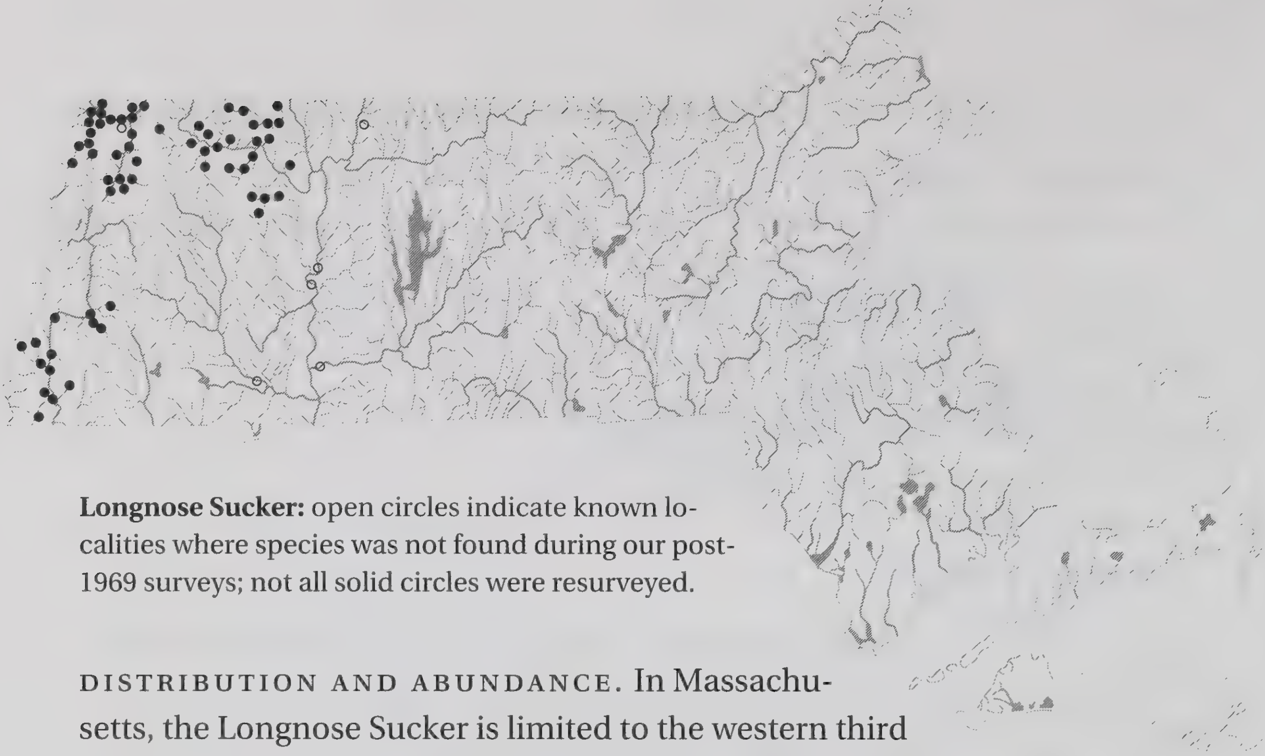


IDENTIFICATION. Longnose Suckers closely resemble White Suckers, but their longer and more pointed snout extends well beyond the subterminal mouth when viewed from below (see key Figure 2a). In addition, they have smaller scales with more than 85 in the lateral series and over 15 scales above the lateral line. Males have a coppery red midlateral stripe during breeding.

SELECTED COUNTS. D 9–11; A 7–9; Scales 88–115.

SIZE. Longnose Suckers are usually 12 to 15 inches TL. Outside of New England, occasional specimens may reach 2 feet TL. Adults from populations in small hill streams are often smaller.

NATURAL HISTORY. In Massachusetts, Longnose Suckers are most often found in the cold, clear streams of the western part of the state. Here they spawn over gravel in early spring. Gravid females and tuberculate males have been noted in the Hoosic and Deerfield rivers between May and early June. Adhesive eggs are deposited over the substrate, but no nest is built. The eggs hatch in 8 to 10 days, and the young move into midwater to feed on plankton. Like other species of suckers, the larvae and postlarvae have a terminal mouth that changes to subterminal as the fishes grow and move to the bottom. Based on Wisconsin data, Longnose Suckers are relatively slow-growing; they take four to five years to reach 8 to 10 inches TL. They may live well over 10 years. Longnose Suckers vacuum a wide variety of aquatic invertebrates and algae off the bottom, including amphipods, copepods, and the larvae of blackflies, beetles, mayflies, dragonflies, stoneflies, and caddisflies.



Longnose Sucker: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, the Longnose Sucker is limited to the western third of the state. It is fairly common in clean, cold portions of the Deerfield, Housatonic, and Hoosic drainages. However, records from 1940 through 1956 show that it occurred historically in the Connecticut and Westfield rivers and at the mouth of the Chicopee River, where specimens have not been collected in recent years. The Longnose Sucker is currently listed as a State Species of Special Concern because of its decline in the lower Connecticut Basin (Connecticut main stem, Westfield, and lower Chicopee rivers) and in parts of the Hoosic and Housatonic drainages as a result of the poor water quality. The pollution and habitat alteration along the main stems have limited surviving populations to the cleaner tributaries (D.G. Smith 1990, pers. comm.).

NOTES. B. McCabe recognized two subspecies of the Longnose Sucker from Massachusetts. *C. c. catostomus* was recognized as a larger form with smaller scales (more than 100) and *C. c. nannomyzon* as a smaller, dwarf form with larger scales (85 to 100). Although the New England populations have not been studied in depth, it is probable that the subspecific status is not warranted.

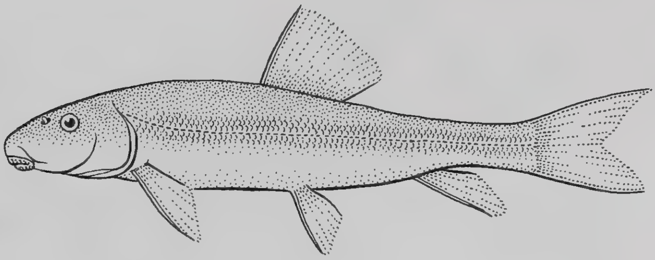
REFERENCES. McCabe 1942, 1943 (distribution, subspecies); Sayigh and Morin 1986 (diet); Becker 1983 (general).

White Sucker

Native

Catostomus commersoni (Lacepède 1803)

PLATES 26, 28

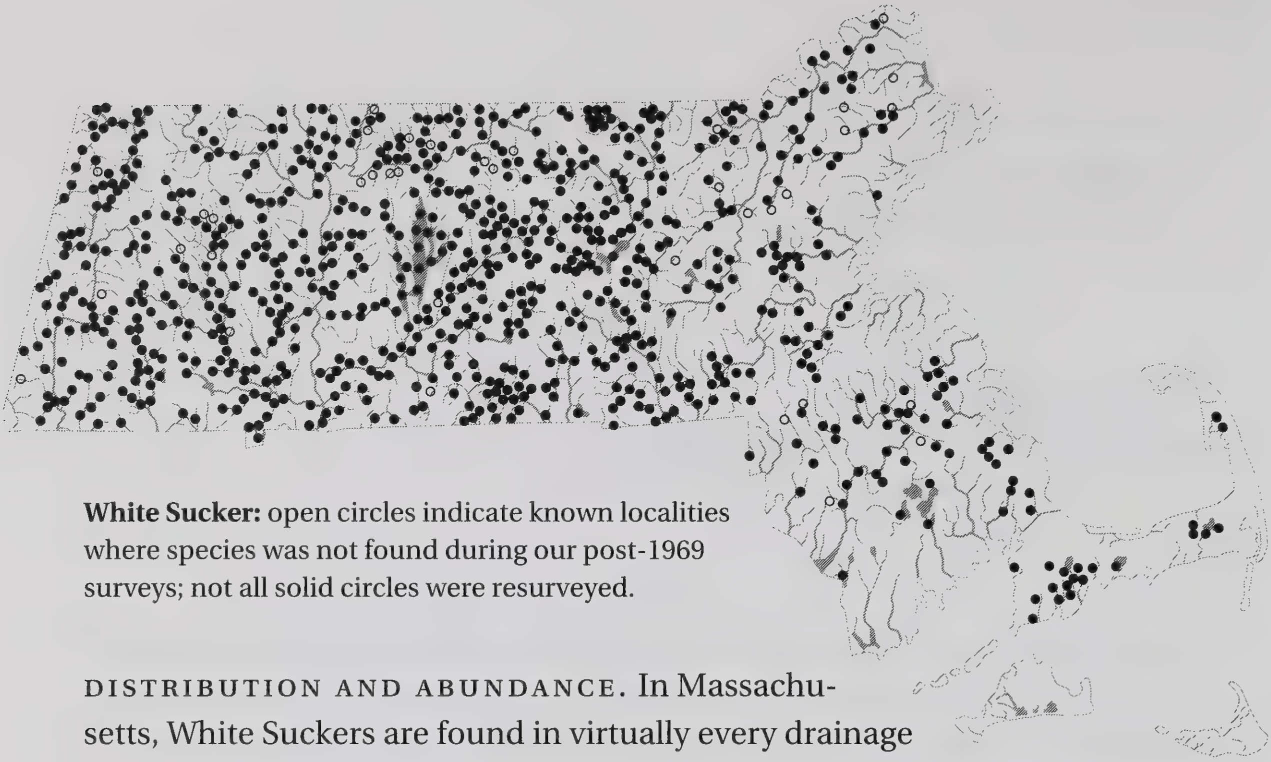


IDENTIFICATION. White Suckers are similar to Longnose Suckers except that their snouts are rounded and barely project beyond the upper lip when viewed from below (see key Figure 2b). White Suckers have fewer than 75 scales in a lateral series and fewer than 11 scales above the lateral line. Three or more irregular lateral blotches are usually present in juveniles and some adults.

SELECTED COUNTS. D 10–13; A 6–8; Scales 53–80.

SIZE. Large specimens may reach 28 to 30 inches TL, but most individuals are less than 2 feet TL.

NATURAL HISTORY. White Suckers live in a wide variety of habitats in Massachusetts. They are most often found in ponds, lakes, and rivers, especially if there are tributaries with gravel runs in which to spawn. Spawning takes place in mid-April to May in Massachusetts, when adults move upstream into tributaries or into shoal areas if tributaries are not available. Mating has been described as a "...tremoring trio, a female tightly flanked on each side by a male" (Jenkins and Burkhead 1993: 641). Sexually mature White Suckers may not spawn every year and exhibit a wide range in size at maturity. Depending on size, females may carry between 20,000 and 139,000 eggs. Young-of-the-year grow quickly and may reach 4.5 inches in length by the end of their first summer. Adults live up to 10 years. Food is mainly benthic invertebrates and fish eggs, but larval midges make up a portion of their diet. While detritus is also often taken in quantity, suckers have the ability to detect food types with taste buds and sort out and expel unwanted items.



White Sucker: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, White Suckers are found in virtually every drainage with the exception of Martha's Vineyard and Nantucket and several of the smaller mainland coastal streams. This species is abundant in many locations.

NOTES. White Suckers are sometimes so common that they are considered "trash" fish. In fact, suckers are a valuable component of our aquatic ecosystem because they reproduce in great numbers and form a large part of the total fish biomass in many areas. In addition, the concept of trash fish is erroneous since it is now generally accepted that every species has a valued place in the ecosystem. Large suckers also put up a good fight when hooked on a light rod, and their flesh, though bony, is quite good, especially in the spring.

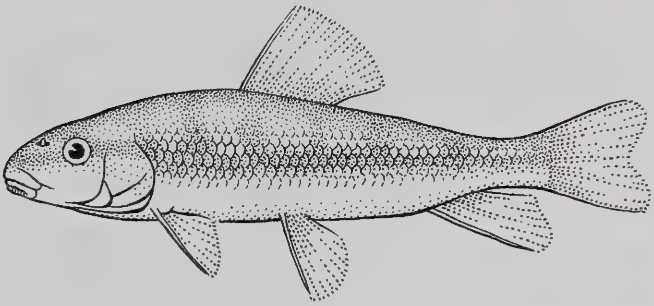
REFERENCES. Bruner 1991 (bibliography); Beamish 1973 (age and growth); Quinn 1982 (age, spawning); Quinn and Ross 1985 (non-annual spawning); Jenkins and Burkhead 1993 (general).

Creek Chubsucker

Native

Erimyzon oblongus (Mitchill 1814)

PLATE 25

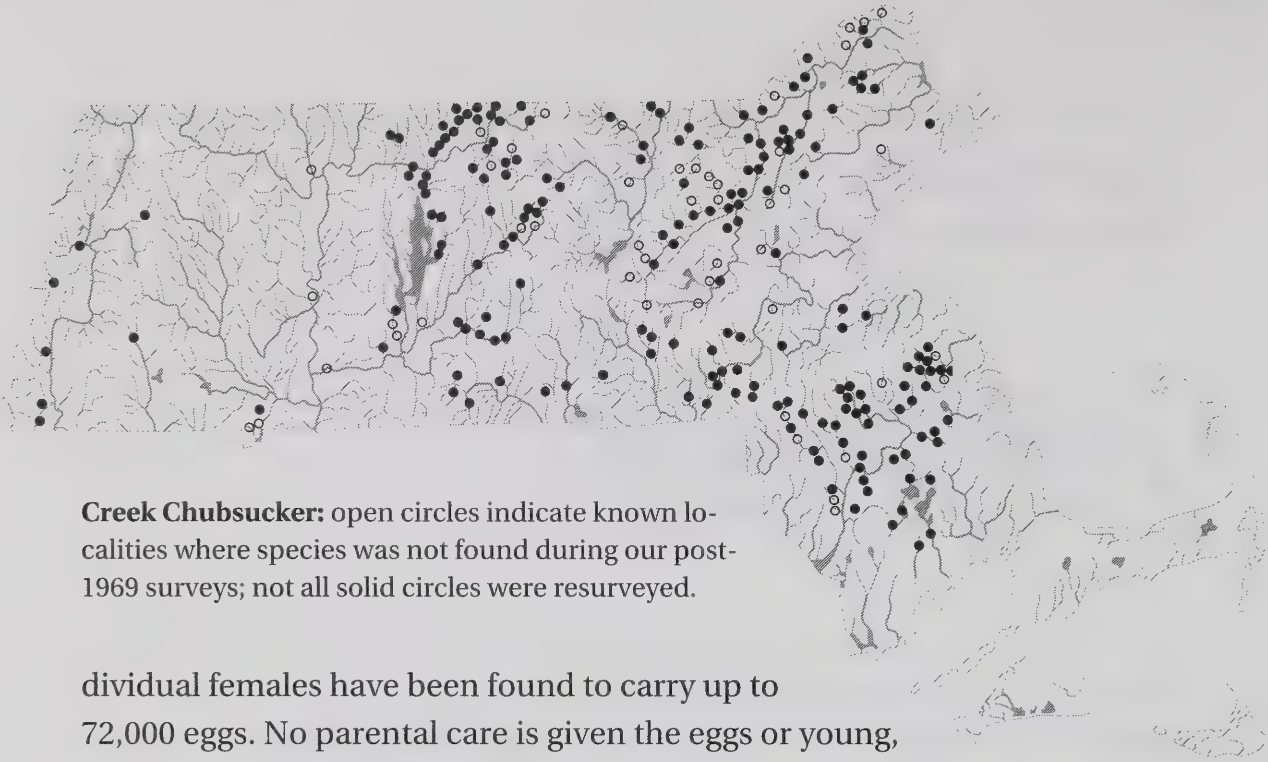


IDENTIFICATION. Creek Chubsuckers are superficially similar to minnows but have pleated and fleshy lips, a posteriorly placed anal fin, and a higher number of dorsal fin rays. The mouth is almost terminal, the scales are large, and lateral-line pores are lacking. Young have a dark brown midlateral stripe from the snout to the base of the caudal fin and a second, less-defined stripe between it and the dorsal midline on a golden-bronze to yellow-brown background. Adults lose these colors although occasional diffuse vertical blotches may be present along the sides of the body.

SELECTED COUNTS. D 11–13; A 7; Scales 41–44 (midbody scales unpored).

SIZE. Creek Chubsuckers are generally less than 9 inches total length, but individuals as large as 18 inches are occasionally encountered outside of Massachusetts. The largest Massachusetts specimen that we examined, from Federal Pond in Carver, measured 14 inches TL (283 mm SL).

NATURAL HISTORY. Creek Chubsuckers are typically found in creeks, streams, and lakes with moderate quantities of aquatic vegetation but are also found in the clear waters of lakes and reservoirs. Creek Chubsuckers feed on plant material and a variety of aquatic and terrestrial invertebrates. As their almost terminal mouth might suggest, they spend a considerable amount of time feeding above the bottom. Creek Chubsuckers spawn in the early spring, but we have never observed them spawning in Massachusetts. From other studies, we know that males grow as large as females, develop large breeding tubercles on the head, and usually spawn in pairs. Creek Chubsuckers do not build nests but defend territories over gravel runs. In-



Creek Chubsucker: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

dividual females have been found to carry up to 72,000 eggs. No parental care is given the eggs or young, and after hatching, the young form schools, feed on zooplankton, and gradually move downstream. After spawning, the adults return to the downstream habitats where they live the rest of the year. Female Creek Chubsuckers can live at least seven years.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, this species is relatively more common east of Quabbin Reservoir but is not known from Cape Cod and the Islands. Surveys between 1970 and 1991 have failed to find this species at a number of localities in Massachusetts where they were found prior to 1969. The areas where they were not collected are scattered throughout their local range, and their absence cannot be attributed to any particular environmental factors. However, they are known to be sensitive to pollutants, especially silt.

REMARKS. Historical reports listed the Lake Chubsucker, *Erimyzon sucetta,* found in the Great Lakes drainages and along the southern East Coast, as part of the Massachusetts fauna. Our review of a large number of specimens demonstrates that the Lake Chubsucker is not found in Massachusetts and that the early accounts were simply mistaken identifications of Creek Chubsuckers.

REFERENCES. Bruner 1991 (bibliography); Gilbert and Wall 1985 (status, southeastern US); Hubbs 1928, (systematics); Page and Johnson 1990 (reproduction); Wagner and Cooper 1963 (population density, growth).

Bullhead Catfish Family

Ictaluridae

Catfishes belong to the order Siluriformes and are closely related to the minnows and suckers. They are a large group of fishes containing over 30 families and at least 2,000 species. Most catfishes, except three families, inhabit freshwaters in temperate to tropical regions of the world. Catfishes have one to four pairs of barbels and heavy skull bones; they typically have sharp spines in their dorsal and pectoral fins and usually lack scales. Catfish spines are often serrated or barbed and have poison glands that can inflict a painful sting. Only two native catfish families are known from New England: the Ictaluridae, endemic to North America, and the Ariidae, a worldwide group of marine catfishes. The sea catfishes, found in coastal waters south of Cape Cod, can be identified by their lack of nasal barbels. The exotic Asian Walking Catfish, *Clarias batrachus,* has also been caught by local anglers but is not reproducing in Massachusetts. The presence of these air-breathing catfishes in Massachusetts is the result of the release of aquarium specimens. Local ictalurids are largely nocturnal and rely heavily on their barbels as sensory devices. The barbels, supported by a small cartilaginous rod and moved by small muscles, have special cells to detect tactile and chemical signals from the environment. These cells, which are also found on the body, play an important role in orientation, schooling, breeding, electrolocation, and feeding. The barbels, sometimes called "whiskers," cannot sting.

REFERENCES. Alexander 1965 (morphology); Raney 1957 (NY); Jones et al. 1978 (early life history, development); Lundberg 1970, 1975, 1982, Fink and Fink 1996 (systematics and relationships); Kendall 1910 (habits, culture, commercial importance); Langlois 1936 (growth); Birkhead 1972 (toxic spines).

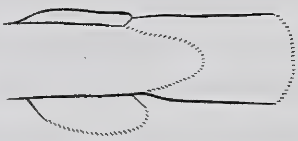
Key to Massachusetts Catfishes

Note: One of the key characteristics separating catfish species is the total number of anal fin rays, including those that may be hidden beneath the skin at the anterior end of the anal fin. Identification of large catfishes can be difficult due to worn and broken tail fins, barbels, or pectoral spines, which are used for identification. Inspection of bony processes of the skull or pectoral girdle may be necessary to identify these questionable specimens, and dissection or radiography may be necessary when a specialist examines the specimens.

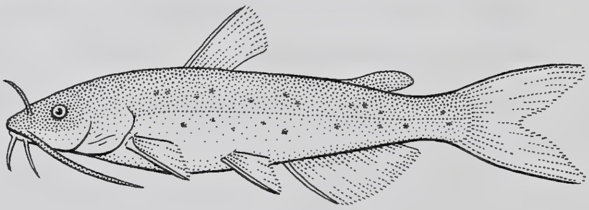
1a. Adipose fin a flag-like fleshy lobe, well separated from caudal fin; tail squared, rounded, or forked; adults to over 24 inches TL. Go to 2.


1a

1b. Adipose fin long, low, and "keel-like," nearly continuous with caudal fin; tail squared or rounded; adults small, seldom over 6 inches TL. Madtoms *Noturus.* Go to 6.


1b

2a. Tail deeply forked, lobes pointed; anal fin with 24 to 30 rays; bony ridge connecting skull and origin of dorsal fin; head relatively small and narrow; young with small spots; larger adults blue-black in color without spots. Channel Catfish, *Ictalurus punctatus,* page 151, Plate 34.

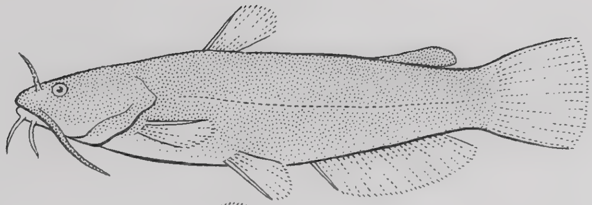


2b. Tail at most moderately forked, lobes more or less rounded; anal fin usually with less than 25 rays; area in front of dorsal fin compressible, without connecting bony ridge; head large and broad; sometimes mottled but never with small spots. Go to 3.

3a. Tail moderately forked, upper lobe usually longer and rounded; gill rakers 18 to 23; head wide and massive; chin barbels light colored. White Catfish, *Ameiurus catus,* page 146, Plate 31.

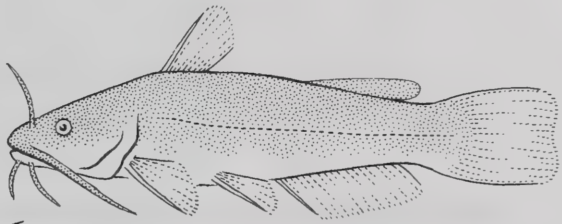
3b. Tail only slightly indented, square or rounded; gill rakers usually fewer than 19 (except the Black Bullhead, *Ameiurus melas*); head large but never massive; chin barbels light or dark. Go to 4.

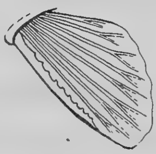
4a. Chin barbels whitish; rear edge of caudal fin nearly straight or slightly rounded; anal fin rays 24 to 28. Yellow Bullhead, *Ameiurus natalis,* page 148, Plate 33.



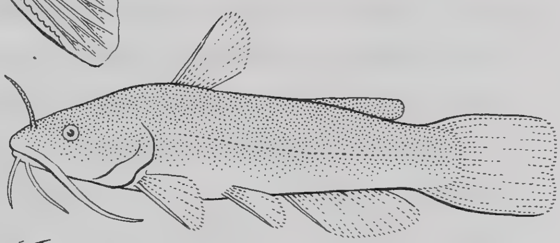
4b. Chin barbels dark; rear margin of caudal fin slightly notched and squarish; anal fin rays fewer than 25. Go to 5.

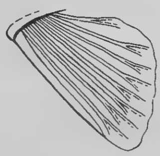
5a. Well-developed serrations on posterior edge of pectoral spine; gill rakers 13 to 15; lacking dark pigment on anal fin membrane. Brown Bullhead, *Ameiurus nebulosus,* page 149, Plate 32.



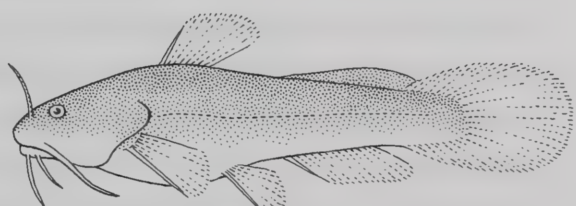


5b. Serrations on pectoral spine poorly developed or absent; gill rakers 16 to 21; dark pigment on membranes of anal fin. Black Bullhead, *Ameiurus melas.* See comments under Brown Bullhead, page 149.





6a. Body short and stout with large head; tail oval and paddlelike, broadly joined to adipose fin; vertical fins without dark edges. Tadpole Madtom, *Noturus gyrinus,* page 153, Plate 35.



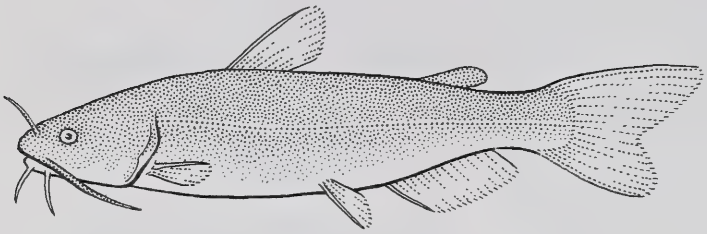
6b. Body more slender and elongate; tail square, only narrowly joined to adipose fin by a low keel; vertical fins often with dark margins. Margined Madtom, *Noturus insignis,* page 155.

White Catfish

Introduced

Ameiurus catus (Linnaeus 1758)

PLATE 31

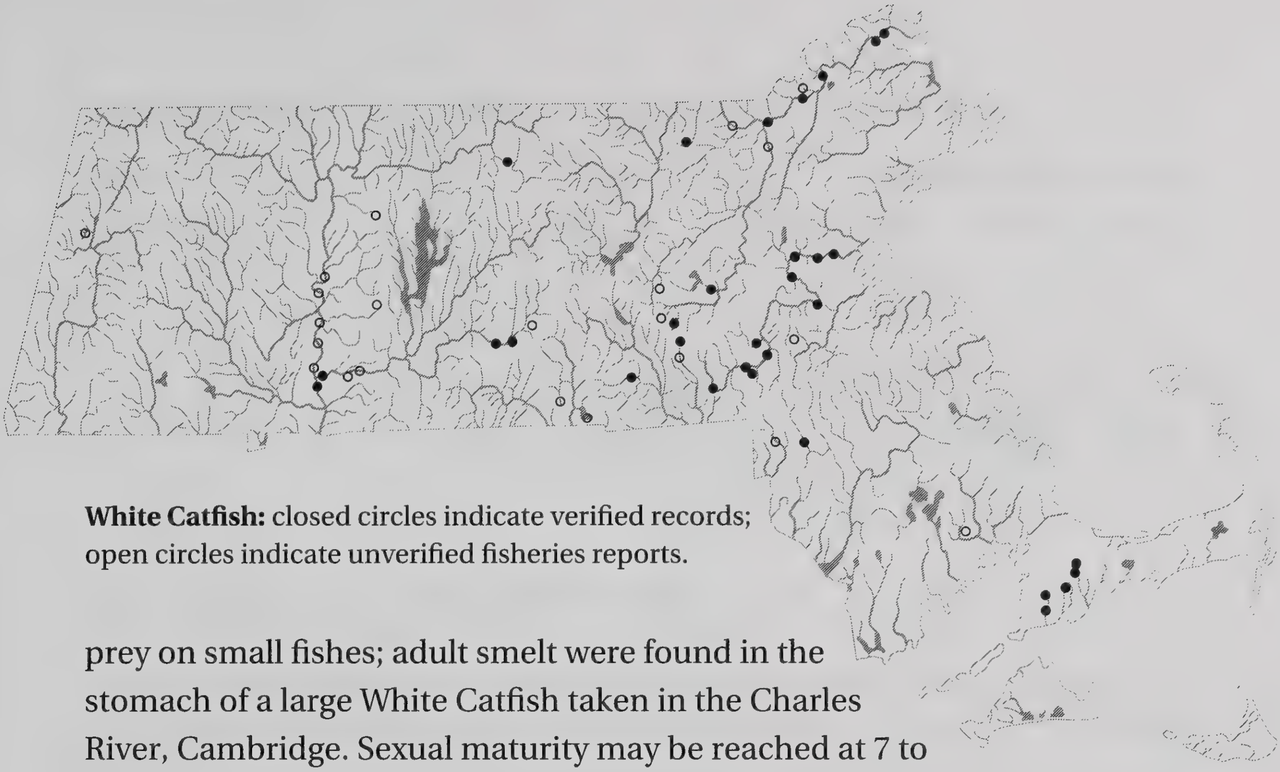


IDENTIFICATION. The White Catfish has a large, wide head with whitish chin barbels. The tail is moderately forked with rounded lobes. The upper lobe is often slightly longer than the lower. The anal fin is relatively short and rounded (less than 25 rays), and this species has 18 to 23 gill rakers. Teeth on pectoral spines are often hooked in young.

SELECTED COUNTS. D i,6; A 22–24; GR 18–23.

SIZE. White Catfishes are intermediate in size between Channel Catfishes and bullheads but have more massive heads. Adults are usually 10 to 18 inches TL and weigh up to 4 pounds. The Massachusetts angling record for a White Catfish is one that weighed 9 pounds, 3 ounces; it was taken at Baddacook Pond, Groton, in 1987. The second largest specimen, taken in 1988, weighed 7 pounds, 11 ounces.

NATURAL HISTORY. The White Catfish inhabits waters that are intermediate between those preferred by Channel Catfishes and bullheads. In Massachusetts, they are found in the main stems of moderately large rivers and a few large ponds. They most frequently inhabit areas with slower currents. They are not found in large numbers either within dense beds of vegetation or in small, muddy, shallow ponds. White Catfishes can tolerate low levels of salinity and may occupy slightly brackish coastal streams and estuaries. Spawning occurs in early summer as water temperatures approach 70°F. Large nests are built near sand or gravel banks. Like other catfishes, they will also spawn in discarded containers and natural cavities. The eggs hatch in six to seven days. The White Catfish is omnivorous, with younger individuals feeding on aquatic invertebrates, plants, and fish eggs. Adults often



White Catfish: closed circles indicate verified records; open circles indicate unverified fisheries reports.

prey on small fishes; adult smelt were found in the stomach of a large White Catfish taken in the Charles River, Cambridge. Sexual maturity may be reached at 7 to 8 inches TL.

DISTRIBUTION AND ABUNDANCE. White Catfishes were introduced as a sport fish in Massachusetts between 1910 and 1949. Reproducing populations currently inhabit the Connecticut, Merrimack, Blackstone, and Charles rivers. In addition, there are records from a number of ponds: Baddacook Pond, Groton; Whitehall Reservoir and North Pond, Hopkinton; Quaboag Pond, Brookfield; and Mashpee-Wakeby Pond on Cape Cod. A number of these sites are based on fisheries or sportfishing records, and the specimens have not been retained or critically examined.

NOTES. White Catfishes are active year-round, and they are often taken while people are icefishing on some of the large ponds.

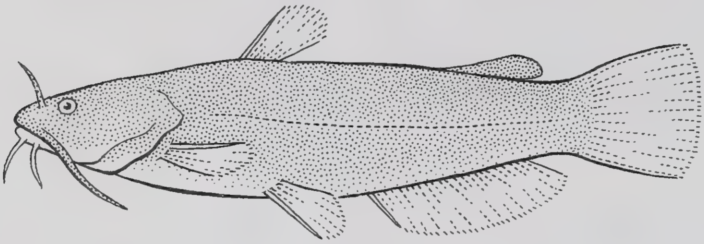
REFERENCES. Sprenger 1990 (Merrimack); Schwartz 1964 (salinity tolerance); Schwartz and Jachowski 1965 (age and growth); Miller 1966a (summary); Kendall and Schwartz 1968 (temperature, salinity tolerance); Kellogg and Gift 1983 (temperature and growth relationships); Arini 1994 (Charles River).

Yellow Bullhead

Introduced

Ameiurus natalis (Lesueur 1819)

PLATE 33



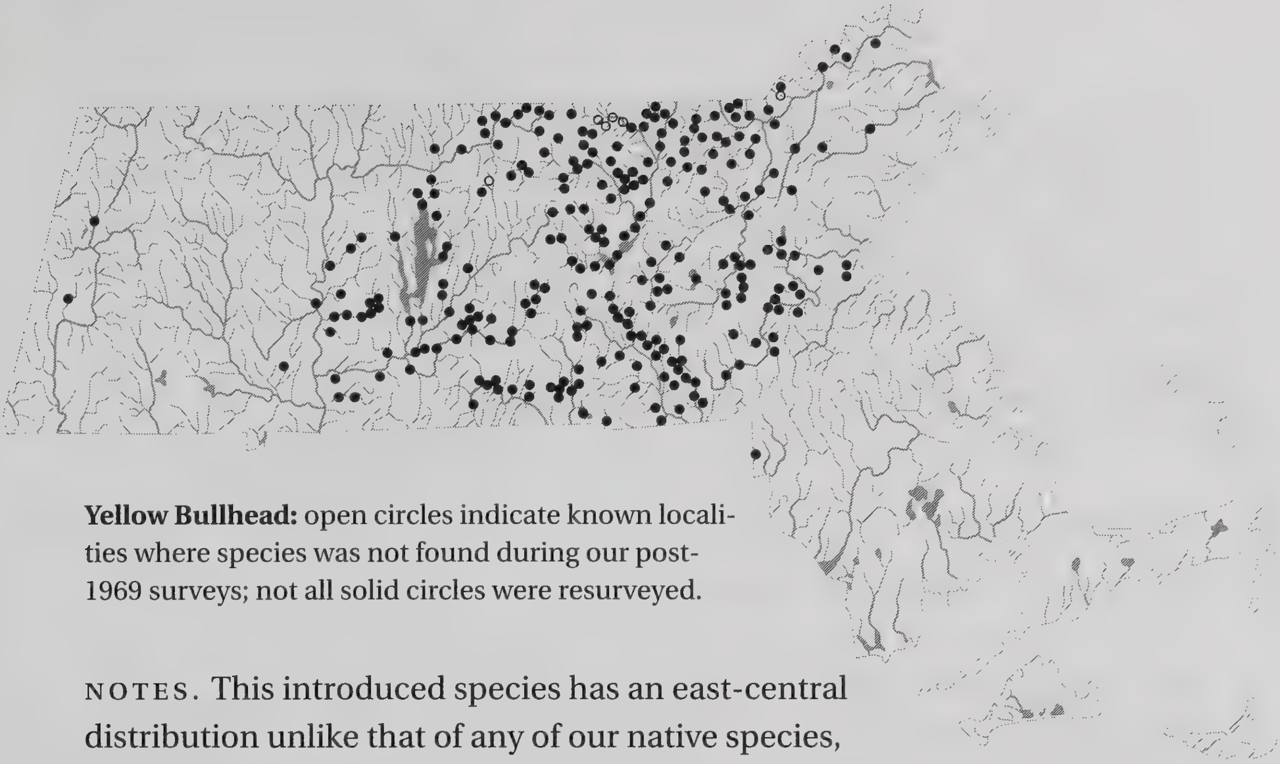
IDENTIFICATION. Yellow Bullheads have square or slightly indented tails with rounded corners and white or light-colored chin barbels. The anal fin is long (24 to 28 rays), and they have a moderate number of gill rakers.

SELECTED COUNTS. D i,6; A 24–28; GR 12–18.

SIZE. Yellow Bullheads are a relatively small species; adults reach 8 to 12 inches TL.

NATURAL HISTORY. Yellow Bullheads generally inhabit moderately or heavily vegetated areas of low-gradient streams and shallow bays of ponds and lakes. They prefer clear water; however, they are somewhat tolerant of silty conditions, particularly in the absence of other competing bullhead species. Sexual maturity is attained by the third summer when they reach 7 to 11 inches TL. Spawning occurs in mid-May to early June and lasts about two weeks. Nests are constructed at depths of 1.5 to 4 feet, and the eggs hatch in 5 to 10 days, depending on the water temperature. Like other bullheads, Yellow Bullheads forage most actively at night. Their diet includes insects, crustaceans, mollusks, and small fishes, as well as some plant material.

DISTRIBUTION. Yellow Bullheads were first introduced into Massachusetts waters in 1917. They are currently found in eastern portions of the Millers and Chicopee drainages as well as in the Thames, Blackstone, Charles, and Merrimack drainages. They are common to abundant and sometimes outnumber the native Brown Bullhead.



Yellow Bullhead: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

NOTES. This introduced species has an east-central distribution unlike that of any of our native species, which reflects its exotic nature. It is found in a block from the eastern tributaries to the Connecticut Basin to the western edges of the coastal systems but not in southeastern areas and Cape Cod.

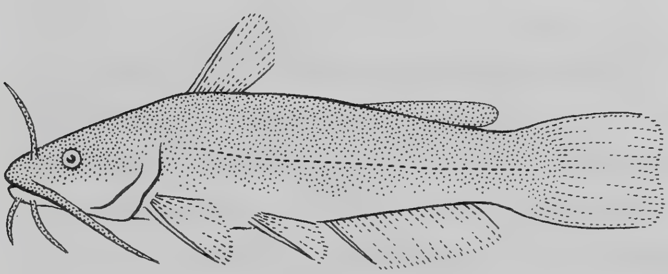
REFERENCES. Fowler 1917 (breeding habits); Fish 1932 (early life history); Schaffman 1955 (age and growth); Todd et al. 1967, Todd 1971 (chemical communication); Reynolds and Casterlin 1977 (activity cycles); Miller 1966b, Trautman 1981 (summaries).

Brown Bullhead

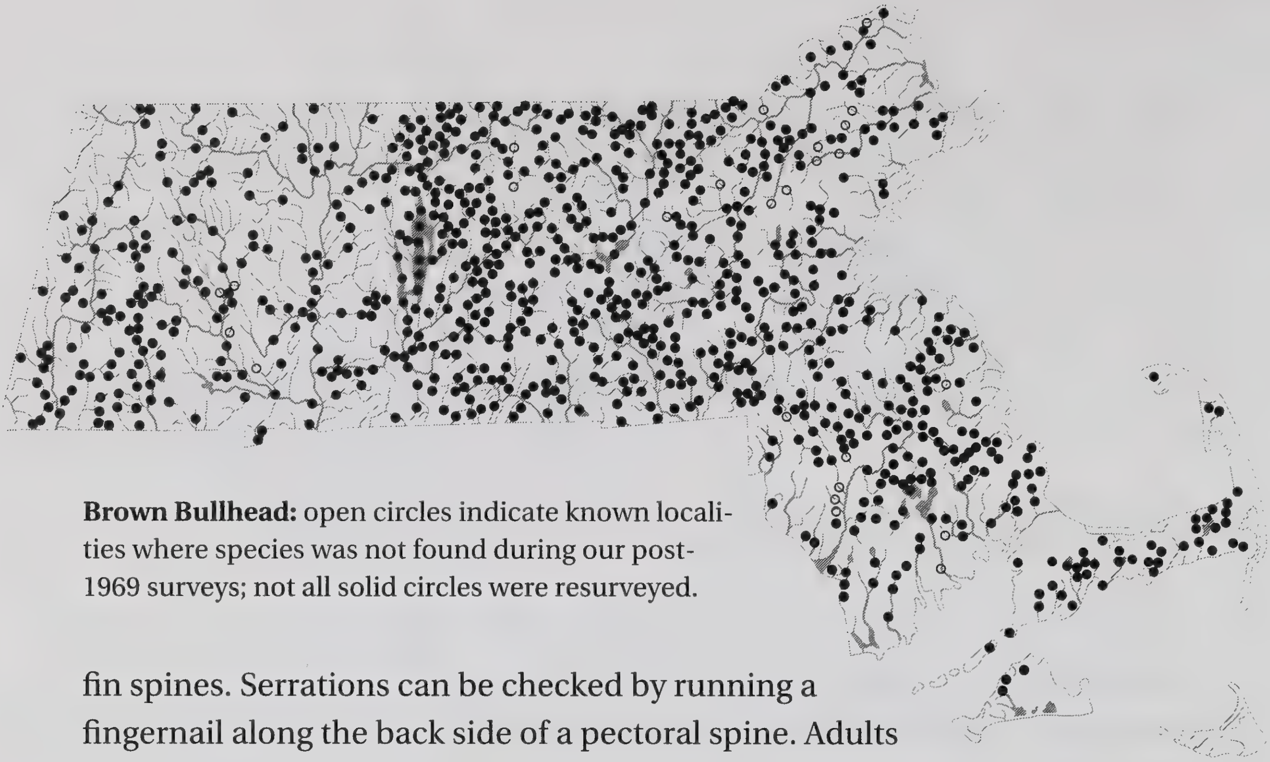
Native

Ameiurus nebulosus (Lesueur 1819)

PLATE 32



IDENTIFICATION. Brown Bullheads have square or only slightly indented tails with rounded corners, brown to black chin barbels, well-serrated pectoral spines, and 13 to 15 gill rakers. They are most similar to the Black Bullhead, *A. melas,* which has 15 to 21 gill rakers and weakly serrated pectoral



Brown Bullhead: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

fin spines. Serrations can be checked by running a fingernail along the back side of a pectoral spine. Adults vary from yellow-brown to almost blue-black dorsally and pale-yellow to white ventrally. Some are mottled brown.

SELECTED COUNTS. D i,6; A 18–24; GR 13–15.

SIZE. Brown Bullheads are medium-sized catfishes that usually reach 8 to 14 inches TL. The Massachusetts sportfish award for the smaller catfishes is awarded for "bullheads," which include Brown and Yellow bullheads. The tied record is held by two Brown Bullheads, each weighing 3 pounds, 8 ounces, and angled from Stiles Pond and Whitehall Reservoir in 1985 and 1987, respectively.

NATURAL HISTORY. Brown Bullheads inhabit lakes, ponds, and backwaters of streams and rivers, with aquatic vegetation and sandy to muddy bottoms. Brown Bullheads are hardy fish and tolerate adverse environmental conditions that exclude other fishes. They are able to survive water temperatures as high as 97°F in the summer as well as oxygen concentrations as low as 0.2 ppm during winter and reportedly are able to survive temporary drought conditions by burrowing into the bottom mud. Brown Bullheads are dormant over the winter and often bury themselves in the mud until spring. They spawn from late May through June when water temperatures rise above 65°F. Like other catfishes, a male and a female assume a head to tail posture during spawning. Females do not attain sexual maturity until they are three years old and 8 to 13 inches long. Males mature at a some-

what smaller size. One or both parents guard the eggs and young; adults stay until the young are 1 to 2 inches TL. The young, in broods of up to 600, remain together in shallow water with aquatic vegetation until the end of the first summer. Brown Bullheads are omnivores, feeding on a wide variety of animal and plant material, particularly during the evening hours.

DISTRIBUTION. Brown Bullheads are the only catfishes native to Massachusetts. They are common to abundant and found in every major drainage but are generally absent from hillstream systems.

NOTES. Brown Bullheads are often called "horned pouts" by anglers in the Northeast. In spite of commonly heard stories, they cannot sting with the barbels. Some Massachusetts specimens have been, on occasion, mistakenly identified as Black Bullheads, *Ameiurus melas,* but only one specimen of the Black Bullhead is confirmed from Massachusetts.

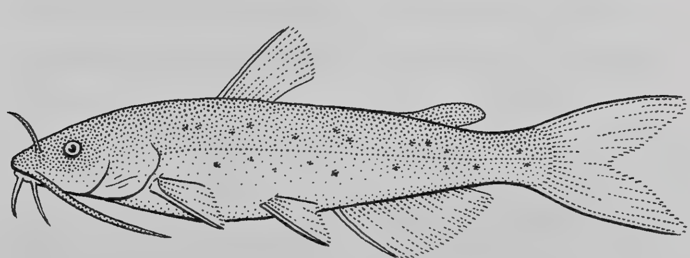
REFERENCES. Breder 1935, 1939 (reproduction); Langlois 1936 (length-weight); Raney and Webster 1940 (food, juvenile growth, NY); Stroud and Bitzer 1955, Grice 1958, Mullan 1959, McCaig et al. 1960 (harvest, management, competition, MA); Loeb 1964 (burrowing behavior); Keast and Webb 1966 (feeding ecology); Hartel 1992 (Black Bullhead records).

Channel Catfish

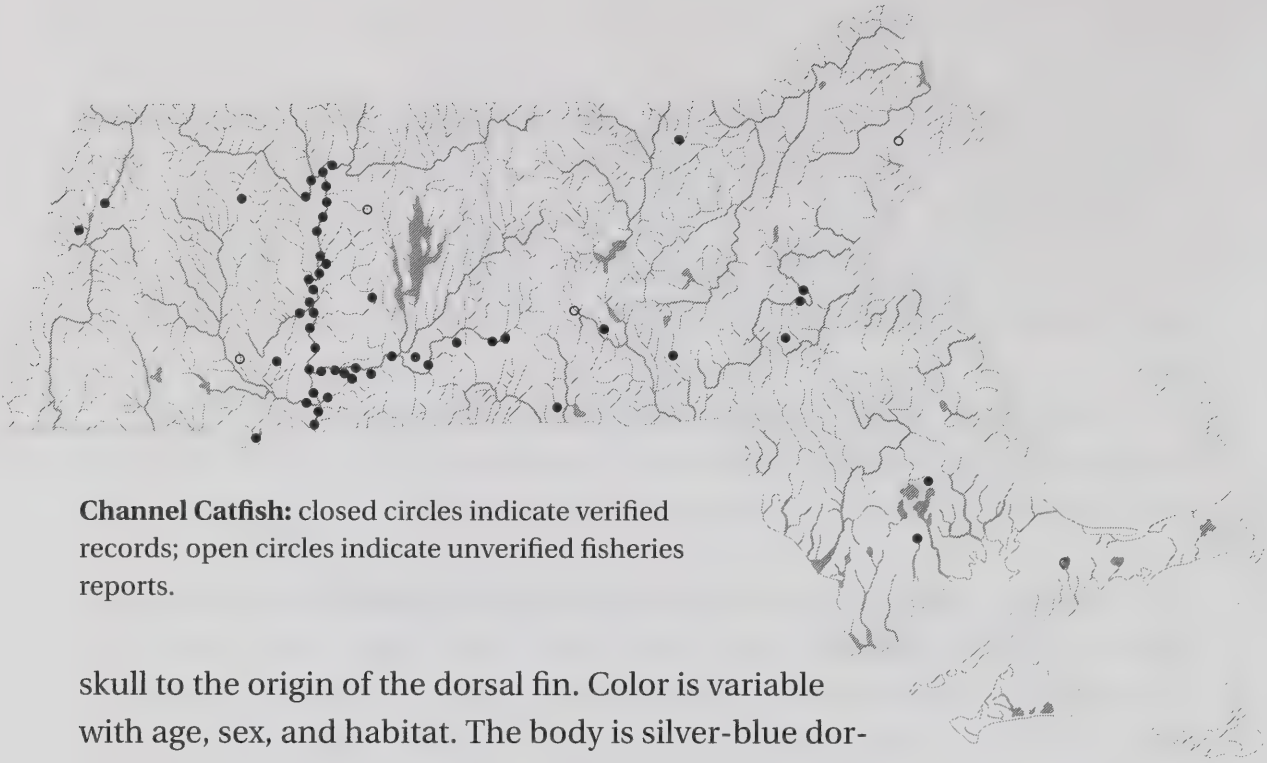
Introduced

Ictalurus punctatus (Rafinesque 1818)

PLATE 34



IDENTIFICATION. Channel Catfishes have a deeply forked caudal fin with pointed lobes, relatively narrow heads, long anal fins with over 24 rays, and dark-colored chin barbels; the barbels at the corner of the mouth are greater than three times as long as those near the nostrils. In addition, they can be distinguished from all bullheads by having a bony ridge that connects the



Channel Catfish: closed circles indicate verified records; open circles indicate unverified fisheries reports.

skull to the origin of the dorsal fin. Color is variable with age, sex, and habitat. The body is silver-blue dorsally to yellow-white ventrally, but larger fishes are often uniformly dark. Scattered black spots are present on the sides of the body in fishes smaller than 12 inches TL.

SELECTED COUNTS. D i,6; A 24–30; GR 13–18.

SIZE. Channel Catfishes are the largest members of the family in Massachusetts. Weights of 2 to 5 pounds are not uncommon, and individuals may reach 10 to 15 pounds. The Massachusetts sportfish record is a 26.5-pound Channel Catfish that was angled from the Ashfield Lake in 1989. Adults may be over 30 inches TL in part of their range.

NATURAL HISTORY. Channel Catfishes inhabit large bodies of water with sand or gravel bottoms that are relatively free of silt. They are seldom found in the shallower, more turbid, vegetated areas frequented by bullheads. Adults tend to be migratory and move into spawning areas in the late spring to early summer when water temperatures approach 70°F. Spawning takes place in secluded nests built by the males in holes beneath undercut banks, rocks, or logjams. Broken drainage tiles or large cans are also used as spawning sites. Young Channel Catfishes reach 2 to 5 inches TL during their first summer and 12 to 18 inches TL before reaching maturity at four to seven years of age. Some individuals may live more than 15 years.

Channel Catfishes feed throughout the water column, from the bottom to the surface. Though considered nocturnal feeders, Channel Catfishes also

feed during the daytime, and they probably use their larger eyes to feed by sight much more than the other catfishes. Channel Catfishes feed on a wide variety of plant and animal matter: the young feed primarily on aquatic insects, while adults are omnivorous, with fish comprising a large part of their diet.

DISTRIBUTION. In Massachusetts, Channel Catfishes were introduced into the Connecticut River between 1920 to 1960. Since that time, their range has expanded to include lower portions of major tributaries to the Connecticut River (Chicopee-Quaboag rivers, Deerfield River). They are also found in a number of larger lakes and ponds such as Baddacook Pond, Groton, and Quaboag Pond, Brookfield. Many records are based on information from fisheries or sportfishers that has not been critically examined.

NOTES. The "farm-raised" commercial catfish meat purchased in most markets is from Channel Catfishes. As one of the largest freshwater fishes in the state, the Channel Catfish is actively sought for sport and food.

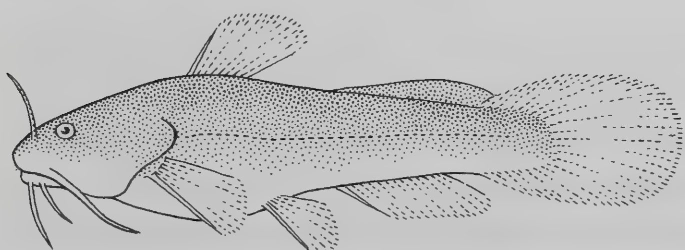
REFERENCES. Bailey and Harrison 1948 (food habits); Marzolf 1955 (age and growth); Clemens and Sneed 1957 (spawning); Moss and Scott 1961 (oxygen requirements); Nowicki and Mann 1989 (Connecticut River, MA); Arini 1994 (Charles River, MA); Schwartz 1964 (salinity); Sneed 1964 (hybridization); Lewis 1976 (food).

Tadpole Madtom

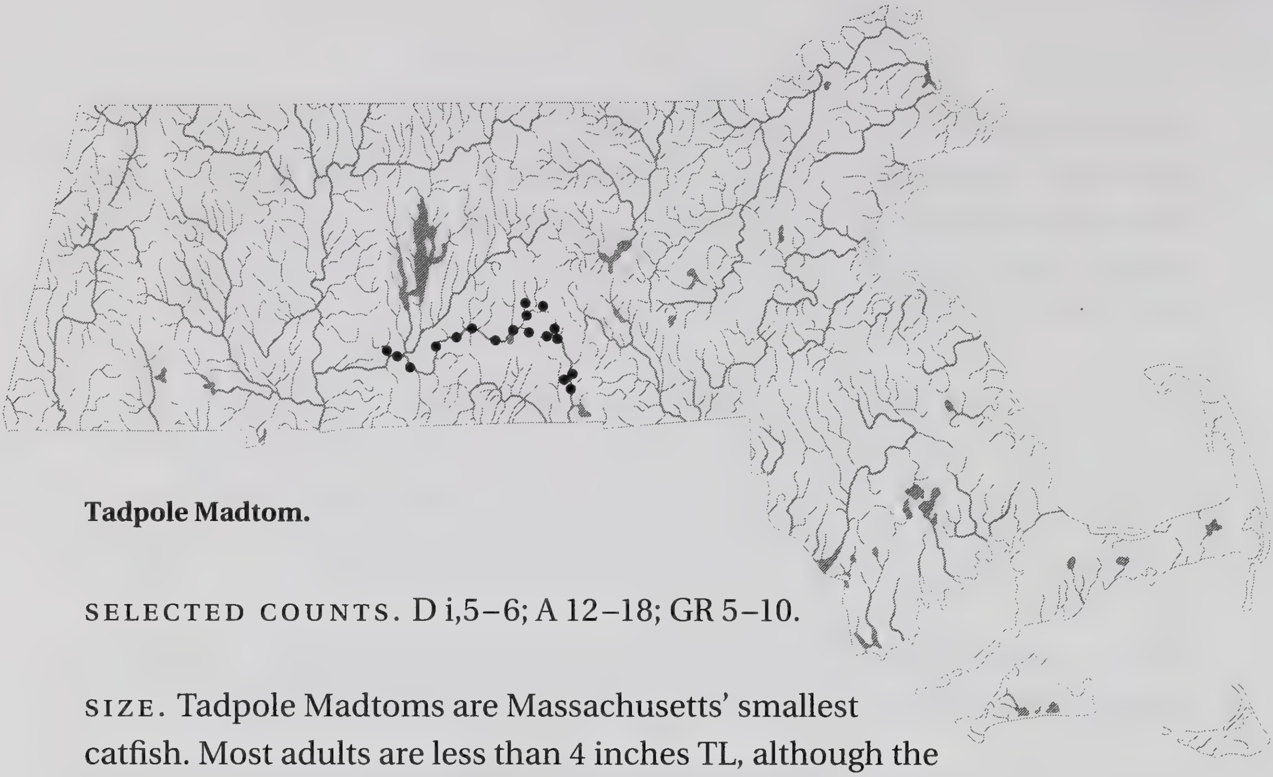
Introduced

Noturus gyrinus (Mitchill 1817)

PLATE 35



IDENTIFICATION. Tadpole Madtoms have well-developed procurrent caudal fin rays that form an oval, paddle-like tail broadly joined to the adipose fin. They are uniformly dark in color with a rather chunky body that somewhat resembles a tadpole of a frog or toad.



Tadpole Madtom.

SELECTED COUNTS. D i,5–6; A 12–18; GR 5–10.

SIZE. Tadpole Madtoms are Massachusetts' smallest catfish. Most adults are less than 4 inches TL, although the species has been known to reach almost 5 inches TL.

NATURAL HISTORY. In Massachusetts, Tadpole Madtoms are most often found in ponds and well-vegetated sections of slow-flowing streams. However, they also inhabit sandy bottomed streams with sparse plant life. Reproduction has not been studied in Massachusetts, but in other parts of their range, this species spawns in the late spring and early summer. Tadpole Madtoms deposit a cluster of relatively large eggs in nest cavities. The adults and egg masses containing up to 100 eggs are often found inside discarded tin cans. Both sexes are known to guard the nest. Tadpole Madtoms are nocturnal and usually feed on a range of small invertebrates, especially isopods and larval midges. Like many small species, Tadpole Madtoms have a short life span, lasting only two to three years.

DISTRIBUTION AND ABUNDANCE. This species was first found in Massachusetts in 1939 at Howe Pond, Spencer, near the headwaters of the Chicopee Drainage. Since then, madtoms have been found as far downstream as the Red Bridge Dam on the Chicopee main stem, and in a number of localities in the French River (Thames Basin). Tadpole Madtoms are common in local areas of both drainages, but they have never been reported in any other parts of the Connecticut Basin in either Massachusetts or Connecticut, nor have they been found in the Thames Drainage below the dam on the French River near the Massachusetts state line. The thousands of unidentified small "horned pouts," stocked in the 1930s, are probably the source of the intro-

duction. Howe Pond, itself, received 5,650 catfishes. New Hampshire's population was considered introduced when first reported in 1938. Based on these facts, we consider the Tadpole Madtom an introduced species in Massachusetts. However, it is also possible that madtoms found in New England are disjunct and relict to populations on the southern Atlantic Coastal Plain (Schmidt 1986).

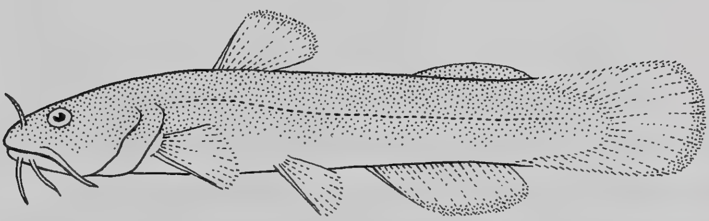
NOTES. Like some other catfishes, the madtoms have sharp pectoral spines associated with venom glands. Tadpole Madtoms are especially unpleasant if handled carelessly. Even a 2- or 3-inch specimen can produce a painful sting, like that of a wasp, which can last for 15 or more minutes.

REFERENCES. McCabe 1948 (first MA record); Bailey 1938 (NH records); Schmidt 1986 (zoogeography); Birkhead 1972 (toxic spines); Smith 1985 (general, NY); Taylor 1969 (systematics and description).

Margined Madtom

Introduced

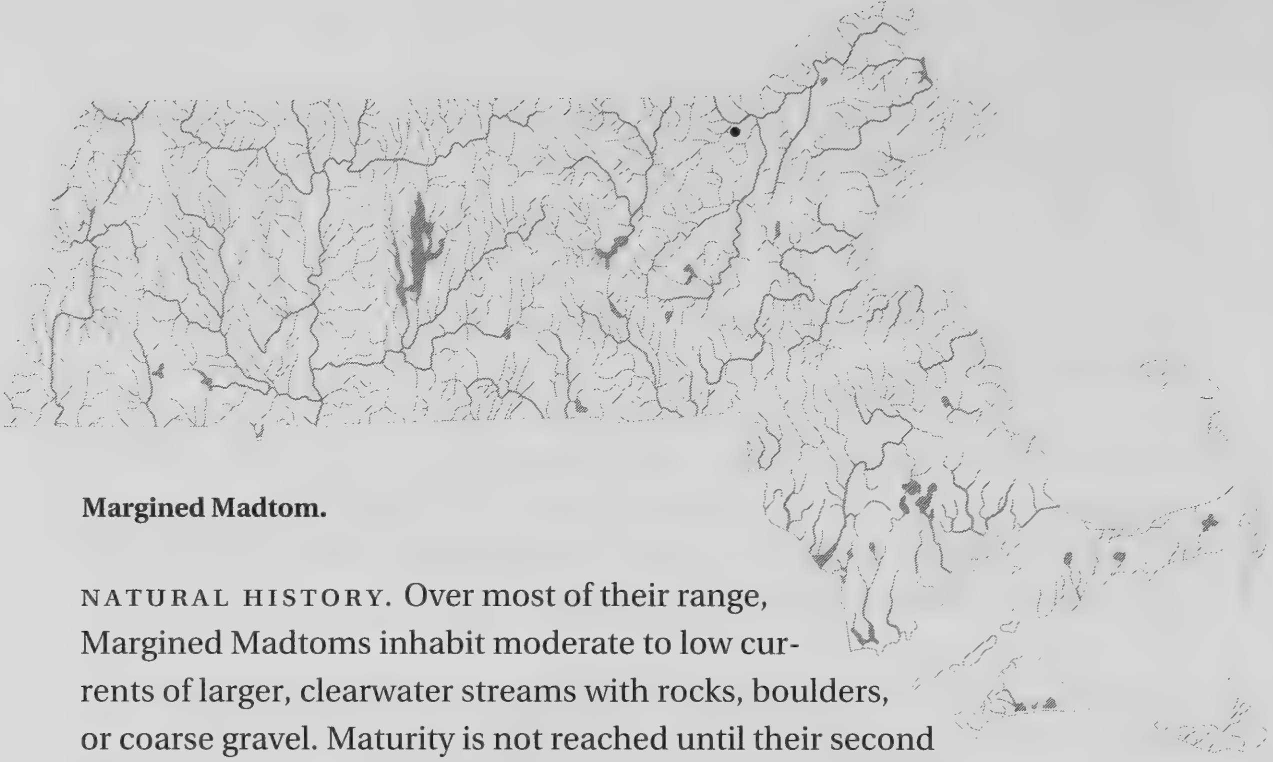
Noturus insignis (Richardson 1836)



IDENTIFICATION. Margined Madtoms are slender and elongate, have a square tail fin, and have small procurrent rays that join the tail to the adipose fin by a low keel. They also have an overshot upper jaw and barbs on the posterior edges of the pectoral spines. Margined Madtoms are slate-gray to yellow-tan dorsally with lighter sides shading to creamy-white beneath the head and belly. The pectoral, dorsal, anal, and caudal fins are often outlined or margined with black.

SELECTED COUNTS. D i,5–6; A 15–21; GR 6–10.

SIZE. Margined Madtoms generally grow to 5 inches TL and rarely exceed 6 inches.



Margined Madtom.

NATURAL HISTORY. Over most of their range, Margined Madtoms inhabit moderate to low currents of larger, clearwater streams with rocks, boulders, or coarse gravel. Maturity is not reached until their second year of life, when they are about 5 inches TL. In Pennsylvania, Margined Madtoms spawn in June, and, over their range, they typically nest under flat stones. Each clutch contains from 50 to 200 eggs. Margined Madtoms are active nocturnal omnivores that eat a large variety of aquatic insects and other invertebrates. During the daytime, they may be found lying passively concealed beneath stones and bottom debris. Margined Madtoms live about four years.

DISTRIBUTION AND ABUNDANCE. Margined Madtoms were first found in Massachusetts during a Division of Fisheries and Wildlife survey in late July 1988 when two specimens 85 and 95mm SL were collected in Crooked Springs Brook, Chelmsford, a tributary to the Merrimack River. R.M. Bailey (1938) considered the Margined Madtom to be an introduced species when he first found it in the Merrimack system in New Hampshire. Although it is possible that the New Hampshire and Massachusetts populations are disjunct relicts (Schmidt 1986), we consider this an introduced species in Massachusetts. See comments under Tadpole Madtom.

NOTES. The sharp pectoral spines have a venom gland at their base, and a painful beelike sting can be inflicted if the fish are handled carelessly.

REFERENCES. Reed 1907, 1924 (poison spines); Fowler 1917 (breeding habits); Bowman 1932, 1936 (ecology, notes); Clugston and Cooper 1960 (growth, PA); Flemer and Woolcott 1966 (food habits); Halliwell 1988 (Merrimack Drainage).

Pike and Pickerel Family

Esocidae

Pike and pickerels are most closely related to the mudminnows and distantly related to salmonids. The pike family is small with only a single genus, *Esox,* and five species that are found only in the Northern Hemisphere. Members of this family have elongated bodies, with the dorsal and anal fins set far back on the body and opposite each other. Their small pectoral and pelvic fins are inserted low on the body. All pickerels and pike lack an adipose fin. Their heads are long with a broad, rather flat snout, and they have a large mouth with numerous, well-developed teeth. The pattern of scales on the cheeks and gill covers is one of the primary taxonomic characters distinguishing species.

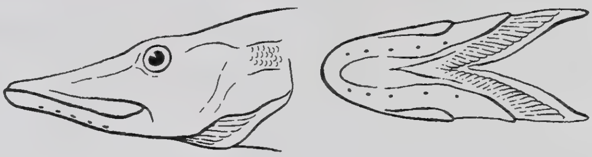
All members of this family are predators; they are "wait and ambush" hunters that hover quietly and then dart forward with a flick of the tail. The larger species are top predators in their food chain and grow to impressive sizes. Spawning occurs in shallow areas with abundant emergent or seasonally flooded vegetation during early spring. Adhesive eggs are broadcast over vegetation, and no parental care is given. One of the most important factors in successful esocid reproduction is water level stability during spawning and early growth because either eggs or young may be stranded by abnormal water level fluctuations in the shallow water breeding areas.

REFERENCES. Wich and Mullan 1958 (life history, ecology, MA); Crossman and Buss 1965 (hybrids); Crossman 1978, Lundberg 1982 (relationships); Casselman et al. 1986 (identification, hybrids).

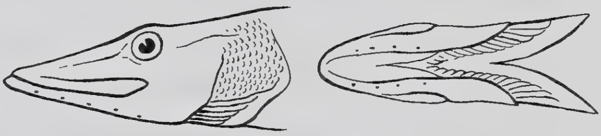
Key to Massachusetts Pike and Pickerels

Note: Hybrids are known between all of these species, and intermediates that do not quite fit the key can occur (see Casselman et al. 1986 for more information).

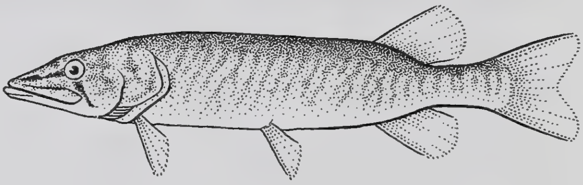
1a. Gill covers not fully scaled; usually 10 submandibular pores (5 on each side). Pike. Go to 3.



1b. Gill covers fully scaled; usually 8 or fewer submandibular pores (4 on each side). Pickerels. Go to 2.

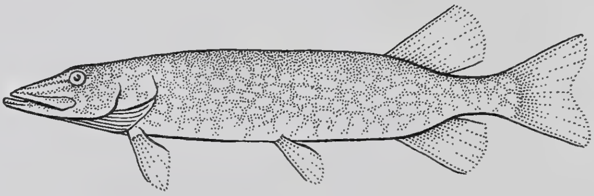


2a. Snout short and convex, about equal to depth of head at mid eye; branchiostegal rays 11 to 12; vertical bars on sides of body; teardrop below eye often slanted backward; lower fins red to orange. Redfin Pickerel, *Esox a. americanus,* page 159, Plate 36.



2b. Snout long and concave, always greater than depth of head at mid eye; branchiostegal rays 13 or more; adults with chainlike markings on sides of body; teardrop below eye usually vertical; lower fins never red or orange. Chain Pickerel, *Esox niger,* page 163, Plate 37.

3a. Pattern of light yellow to white, bean-shaped spots on a darker body color. Northern Pike, *Esox lucius,* page 161.



3b. Pattern of vertical dark bars on a silvery or light body color (but pattern may be variable). Tiger Muskie, *Esox lucius* × *E. masquinongy.* See comments under Northern Pike, page 161.

Redfin Pickerel

Native

Esox americanus americanus Gmelin 1788

PLATE 36

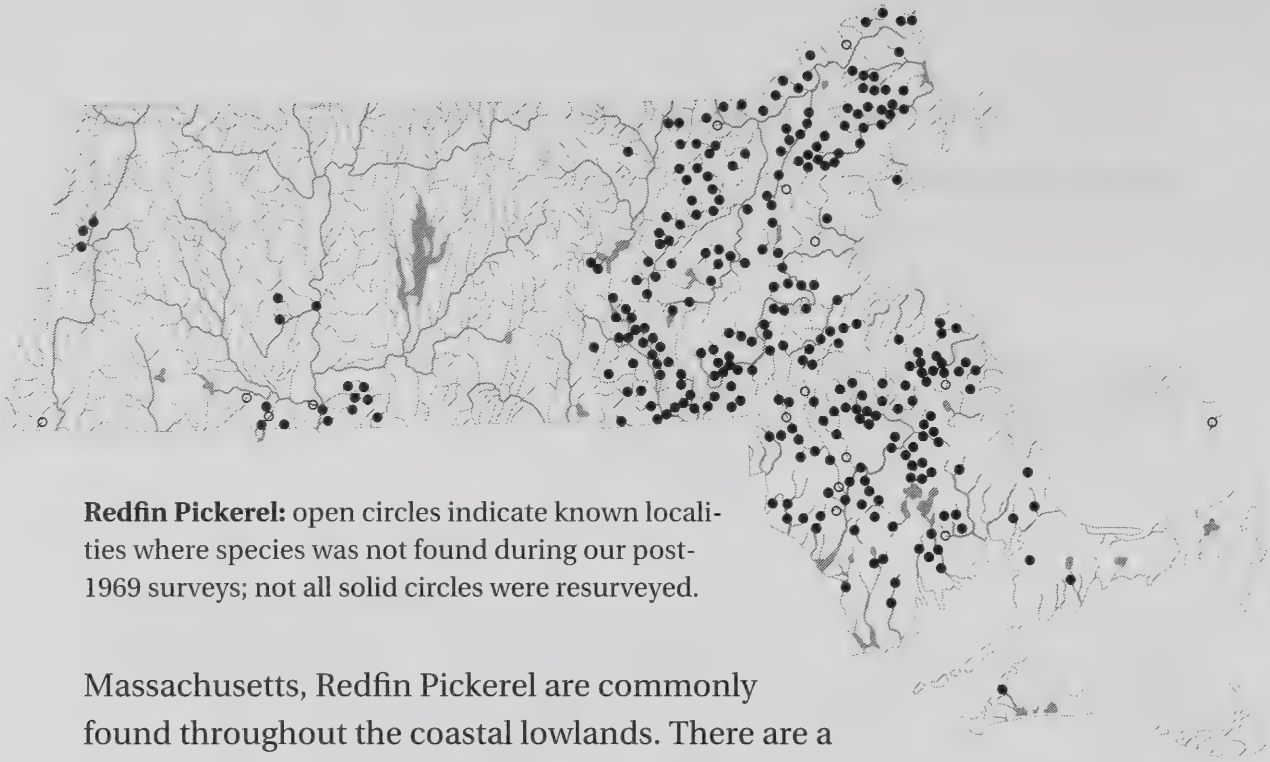
IDENTIFICATION. Redfin Pickerel have fully scaled cheeks and opercula; a short, convex snout; vertical barring on the back and sides; and reddish lower fins. The dark bar below the eye usually slants slightly backwards. Variable color is most often dark green to brown-green above, shading to grass-green laterally, and creamy white ventrally. Juveniles (2 inches or smaller) are uniformly darker than adults and do not have prominent vertical bars.

SELECTED COUNTS. D 15–18; A 13–17; Scales 94–116; Branchiostegals 12–13; Submandibular pores 4 (3–5).

SIZE. Redfin Pickerel are the smallest esocids; adults are almost always less than 12 inches TL. The largest Massachusetts specimen that we have measured is just over 7 inches TL (160 mm SL).

NATURAL HISTORY. Prior to translocation by humans, Redfin Pickerel were restricted to low elevation areas with slow-moving, often naturally acidic streams and small ponds. Redfin Pickerel spawn early in spring when water temperatures approach 50°F—probably April to May in Massachusetts. Spawning occurs along heavily vegetated flooded margins of small streams and ponds. Redfin Pickerel mature in two to three years and may live up to seven years. Adults prey mostly on small fishes and crayfishes; juveniles feed primarily on aquatic insects and other invertebrates. Voracious predators, these small pickerel use an ambush style of hunting like their larger relatives, but on much smaller prey.

DISTRIBUTION. The Redfin Pickerel is the eastern subspecies of *Esox americanus,* which has a western subspecies called *E. a. vermiculatus.* In



Redfin Pickerel: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

Massachusetts, Redfin Pickerel are commonly found throughout the coastal lowlands. There are a few records of this species from the floodplain of the Connecticut River, just north of the Connecticut state line. Redfin Pickerel found in the Housatonic Drainage are the result of introductions.

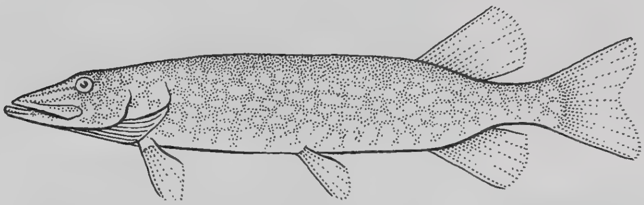
NOTES. Also called "bulldog" or "mud" pickerel, this species is often mistaken for juvenile Chain Pickerel. Before the introduction of Largemouth Bass into its Massachusetts range, Redfin Pickerel was the top predator in a coastal fauna that includes Swamp Darters and Banded Sunfish. Redfin Pickerel readily hybridize with Chain Pickerel and produce fertile hybrids, which are common in Massachusetts.

REFERENCES. Buss 1962, Crossman 1962 (life history, ecology); Crossman 1966, 1978 (taxonomy and distribution); Chang 1979 (food habits); Raney 1955 (hybrids, MA).

Northern Pike

Introduced

Esox lucius Linnaeus 1758

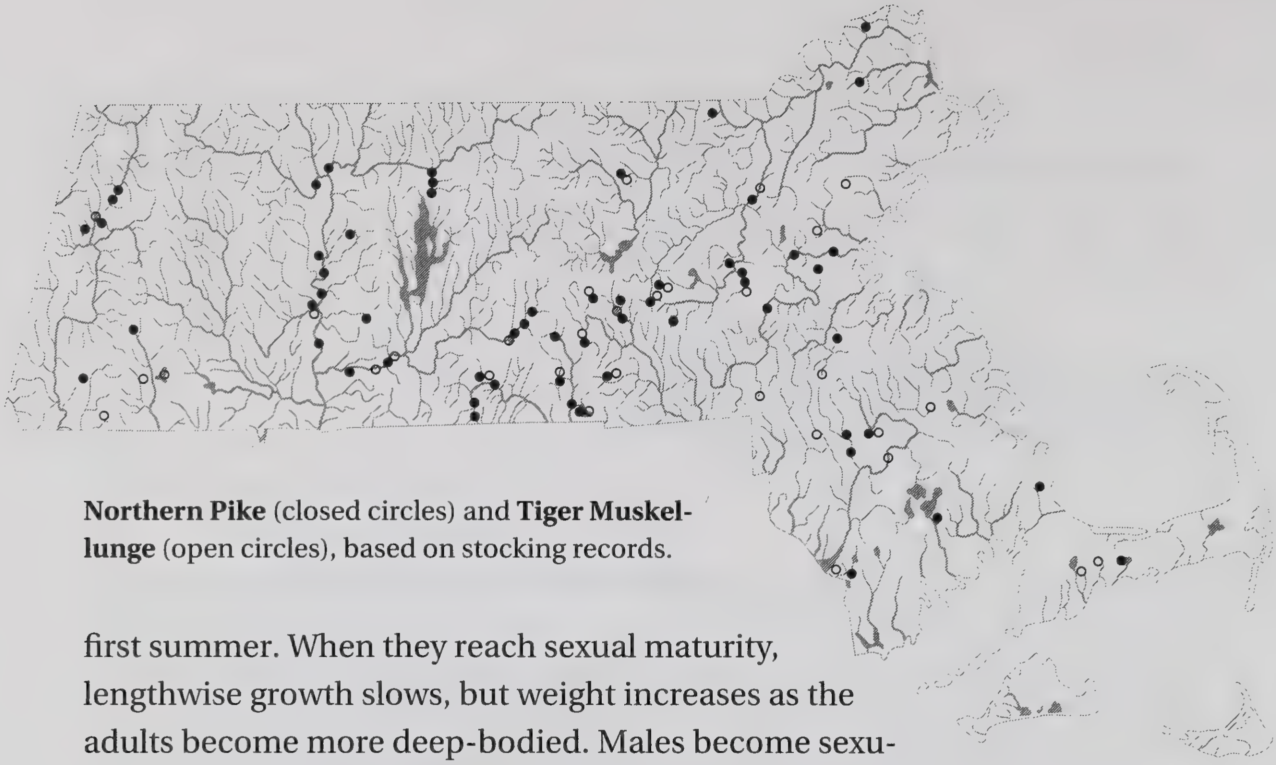


IDENTIFICATION. Northern Pike have scales on the cheek and on the upper half of the operculum. They also have a total of 10 to 11 submandibular pores, whereas pickerels usually have 8 or fewer total pores. The color pattern of light, bean-shaped spots on a dark background separates the Northern Pike from the hybrid Tiger Muskellunge ("Muskie"), which has a vertically striped pattern on the body. In young Northern Pike, the spots are less numerous and arranged in vertical rows that appear as bars.

SELECTED COUNTS. D 15–19; A 12–15; Scales 105–148; Branchiostegals 14–15; Submandibular pores 5 (3–6).

SIZE. Northern Pike are large fish, although not quite so large as Muskellunge. Lengths of 19 to 37 inches TL and weights of 2 to 12 pounds are most common, but some Northern Pike grow to 4 feet or more. The Massachusetts angling record for Northern Pike weighed 35 pounds when caught through the ice in 1988 at South Pond in East Brookfield. The largest Massachusetts Tiger Muskie weighed 19.4 pounds when taken from Lake Quannapowitt in 1994.

NATURAL HISTORY. In Massachusetts, Northern Pike generally spawn from late March to April, when water temperatures exceed 40°F. A large female and one or two smaller males form a spawning group that swims into vegetation where eggs and sperm are released as the fish vibrate their bodies. Spawning is repeated many times over 2 to 5 days, and the fertilized eggs adhere to vegetation and hatch in 12 to 14 days. The half-inch-long fry attach themselves to vegetation for 6 to 10 days by means of a special adhesive gland on the head before they begin to feed. Growth is rapid for one to three years with juveniles growing to about 6 inches TL by the end of their



Northern Pike (closed circles) and **Tiger Muskellunge** (open circles), based on stocking records.

first summer. When they reach sexual maturity, lengthwise growth slows, but weight increases as the adults become more deep-bodied. Males become sexually mature in two or three years, while females mature in three or four years. Growth rates vary with the sex of the fish, length of the growing season, water temperature, and food availability. Young pike feed on large zooplankton and immature aquatic insects for three to four weeks before they begin to eat small fishes. As top carnivores, adult Northern Pike are voracious and highly specialized predators that consume a wide variety of prey, ranging from fishes to birds and small mammals.

DISTRIBUTION. Northern Pike are not native to Massachusetts but were introduced into the Connecticut River in Vermont and New Hampshire by the mid-1800s. They were first observed in the Connecticut River in Massachusetts by 1846. These early introductions met with little success, except for a small population that became established in the Easthampton Oxbow of the Connecticut River. Introductions of Lake Champlain stock in the early 1950s established populations in a number of western Massachusetts ponds, including Cheshire Reservoir and Onota Lake. Since that time, Northern Pike, and more recently Tiger Muskellunge, have been routinely stocked statewide as a sport fish and as a management tool to control overabundant or stunted forage fish populations.

NOTES. The Tiger Muskellunge is a sterile hybrid between Northern Pike and Muskellunge, *Esox masquinongy*. An overall color pattern of light spots on a dark background separates the Northern Pike from the Tiger Muskie, which has a vertically striped pattern on the body.

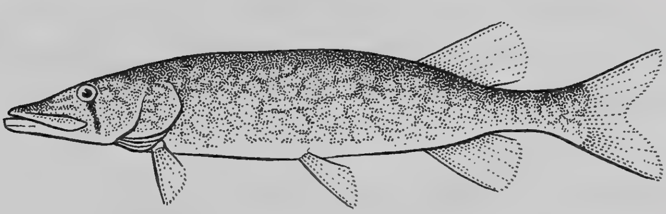
REFERENCES. Crossman and Casselman 1987 (bibliography); Raat 1988 (synopsis); Oatis and Lindenberg 1980 (management in MA); Anon. 1846, Storer 1846 (introductions).

Chain Pickerel

Native

Esox niger Lesueur 1818

PLATE 37



IDENTIFICATION. Chain Pickerel have fully scaled cheeks and gill covers; long, slightly concave snouts; eight or fewer total submandibular pores; and a nearly vertical bar beneath the eye. The pattern of narrow, black lines against a bright brassy to pale green background forms a chainlike, reticulated pattern.

SELECTED COUNTS. D 14–15; A 11–13; Scales 117–135; Branchiostegals (14)15(17); Submandibular pores 4(5).

SIZE. Chain Pickerel are intermediate in size between the smaller Redfin Pickerel and the larger Northern Pike and Muskellunge. In Massachusetts, the average length of three-year-old Chain Pickerel is 13 inches TL, but lengths of 15 to 19 inches (1 to 2 pounds) may be attained in more productive waters. Older individuals may reach 24 inches and weigh 3 to 4 pounds. The Massachusetts state angling record is a 9-pound, 5-ounce (29.5 inches TL) fish taken through the ice from Laurel Lake (Berkshires) in 1954.

NATURAL HISTORY. Chain Pickerel occur in a wider range of habitats than other esocids and may even be found in brackish waters with salinities up to 23 parts per thousand. They typically live in ponds and quiet backwaters of medium to large rivers and are usually less common in smaller streams inhabited by Redfin Pickerel. The onset of spawning is variable with latitude and spring conditions; however, Chain Pickerel move into spawning areas after the ice melts and begin to spawn when water temperatures approach

Chain Pickerel: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

47° to 52°F. In Massachusetts, spawning usually occurs from March to May. Chain Pickerel lay yellowish eggs in glutinous strings (up to 9 feet long) in swampy, marshy, or flooded areas with abundant submerged aquatic vegetation. Eggs hatch in 6 to 12 days, depending on the water temperature. After hatching, the fry do not feed for six to eight days while they absorb the yolk sac. Chain Pickerel may live at least eight years. Food habits and feeding behavior are similar to those of other esocids. Juveniles feed on smaller invertebrates and fishes, but the adults become highly piscivorous as they grow. Larger Chain Pickerel will eat small mammals, frogs, and snakes.

DISTRIBUTION. Chain Pickerel are generally common and widely distributed statewide in Massachusetts, occurring in suitable habitats within all major drainages. We are not sure if they were naturally distributed on Nantucket and Martha's Vineyard prior to stocking.

NOTES. The Chain Pickerel is an important, native, warmwater game fish in Massachusetts due to its widespread occurrence, relatively large size, and year-round feeding behavior. Like pike, pickerels are often taken through the ice during the winter months.

REFERENCES. Crossman and Lewis 1973 (bibliography); Wich and Mullan 1958 (life history, ecology); Crossman 1978 (taxonomy); Rand and Lauder 1981 (prey capture); Raney 1955 (hybridization); Fiske et al. 1968 (salinity).

Mudminnow Family

Umbridae

The Mudminnow family is a small group of fishes closely related to the pickerel and pike (Esocidae). The five species of umbrids have small, non-overlapping distributions that pose interesting zoogeographic questions about widely separated but closely related species. One species, the Alaska Blackfish, *Dallia Pectoralis,* is found only in western Alaska and another, the Olympic Mudminnow, *Novumbra bubbsi,* is limited to a small area of the Olympic Peninsula in Washington. The remaining species are placed in *Umbra,* with the Eastern Mudminnow, *Umbra pygmaea,* found on the East Coast of the United States, the Central Mudminnow, *Umbra limi,* native to the Great Lakes region, and *U. krameri* found in eastern Europe. With the exception of the Alaska Blackfish, mudminnows are small, usually less than four inches in length, and have stout bodies. They have nonprotrusible upper jaws and lack spines in their fins. Mudminnows breathe atmospheric oxygen using a modified swim bladder, which enables them to survive in habitats that become seasonally anoxic.

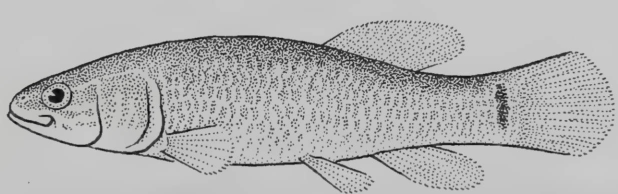
REFERENCES. Cavender 1969, Wilson and Veilleux 1982, Martin 1984 (fossils, osteology, larvae, and relationships).

Central Mudminnow

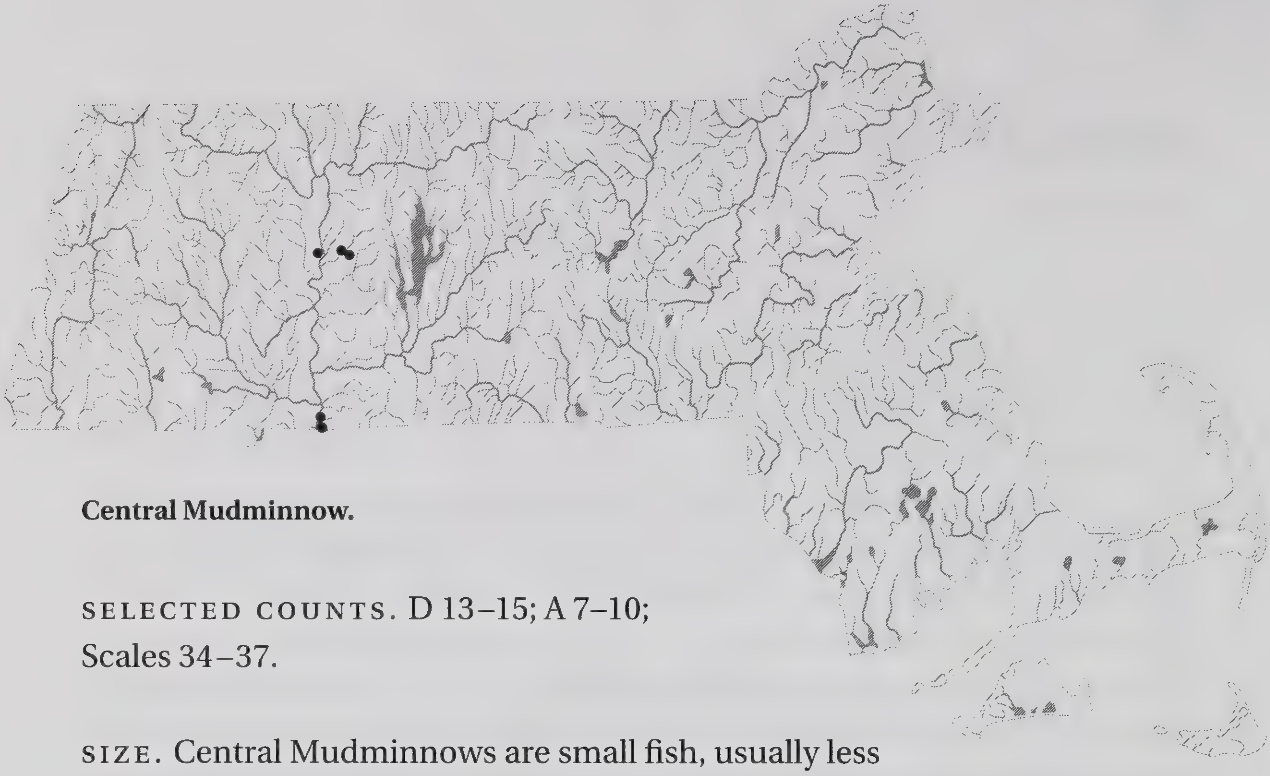
Introduced

Umbra limi (Kirtland 1840)

PLATE 29



IDENTIFICATION. Central Mudminnows are stout-bodied, with rounded and opposed dorsal and anal fins that are set far back on the body. They resemble killifishes (Fundulidae), but mudminnows lack a protrusible upper jaw and the groove between the snout and the upper jaw. A dark vertical bar is usually found at the base of the tail.



Central Mudminnow.

SELECTED COUNTS. D 13–15; A 7–10; Scales 34–37.

SIZE. Central Mudminnows are small fish, usually less than 5 inches TL. The largest Massachusetts specimen that we have seen measured 98 mm SL.

NATURAL HISTORY. The natural history of the Central Mudminnow in Massachusetts has not been studied, but, in other areas, they prefer vegetated waters that have little or no current. Small, sluggish streams and quiet bays of lakes are common habitats, and in periods of high water, mudminnows readily swim into areas of submerged terrestrial vegetation. During the late spring to early fall, Central Mudminnows are closely associated with the vegetation and are most active in the early mornings and late evenings. In the cooler periods of the year, individuals generally move out of the shallows and into the deeper waters. In some areas, mudminnows are active throughout the winter, but this species is reported to burrow into the substrate and aestivate (a form of dormancy) during the warmest parts of the summer. Spawning occurs in mid- to late spring and is apparently associated with high water levels and a rise in water temperature. Central Mudminnows may migrate upstream short distances to find suitable spawning areas. Females have been found to carry up to 2,000 eggs. Their diet is varied, but they frequently take small invertebrates, particularly amphipods and aquatic beetles, as well as small fishes and vegetation.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Central Mudminnows have been found in only a few locations near the Connecticut River between Sunderland and Longmeadow. The introduction of this species to

Massachusetts most likely resulted from the release of laboratory specimens from the University of Massachusetts, Amherst, during the mid-1960s. The exact date of the introduction is unknown, but the first specimens were taken in the wild in 1975.

NOTES. Central Mudminnows are able to breathe atmospheric oxygen and to survive in waters where other fishes are excluded. It has been estimated that one-quarter to one-third of its usual oxygen consumption occurs through aerial respiration, which increases during adverse conditions. Similar to some other fishes that breathe air, the mudminnow gulps air and forces it into its highly vascularized swim bladder, which functions as a lung. Air breathing is also enhanced by adaptations of the blood vessels that carry blood more directly and more efficiently to the heart.

REFERENCES. Chapman 1934 (osteology); Chilton et al. 1984 (winter feeding); Colgan and Silburt 1984, Martin-Bergmann and Gee 1985, Peckham and Dineen 1957, Tonn and Paszkowski 1987 (ecology); Gee 1980 (air breathing).

Smelt Family

Osmeridae

The smelt family consists of seven genera and about 13 species. Found in the northern oceans, they are mostly marine or anadromous, but some live their full life in freshwater. Smelt are closely related to the salmon and trout. Only two species are found in the western North Atlantic, Rainbow Smelt and Capelin, *Mallotus villosus.* Capelin are strictly marine and do not range as far south as Massachusetts. Smelt are characterized by an adipose fin, a slender body form, and numerous teeth on most of the bones in the mouth. Freshly caught members of the smelt group are said to have a distinct odor, like fresh cucumbers. Whatever the scent, it is one of the characteristics that have been used to unite this group of interesting and important fishes.

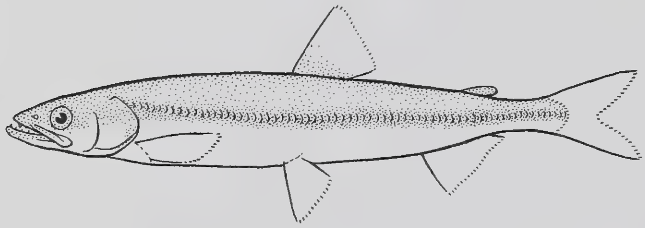
REFERENCES. Hearne, 1984 (development and relationships); Johnson and Patterson 1996 (relationships), McAllister, 1963 (review); McDowall et al. 1993 (odor).

Rainbow Smelt

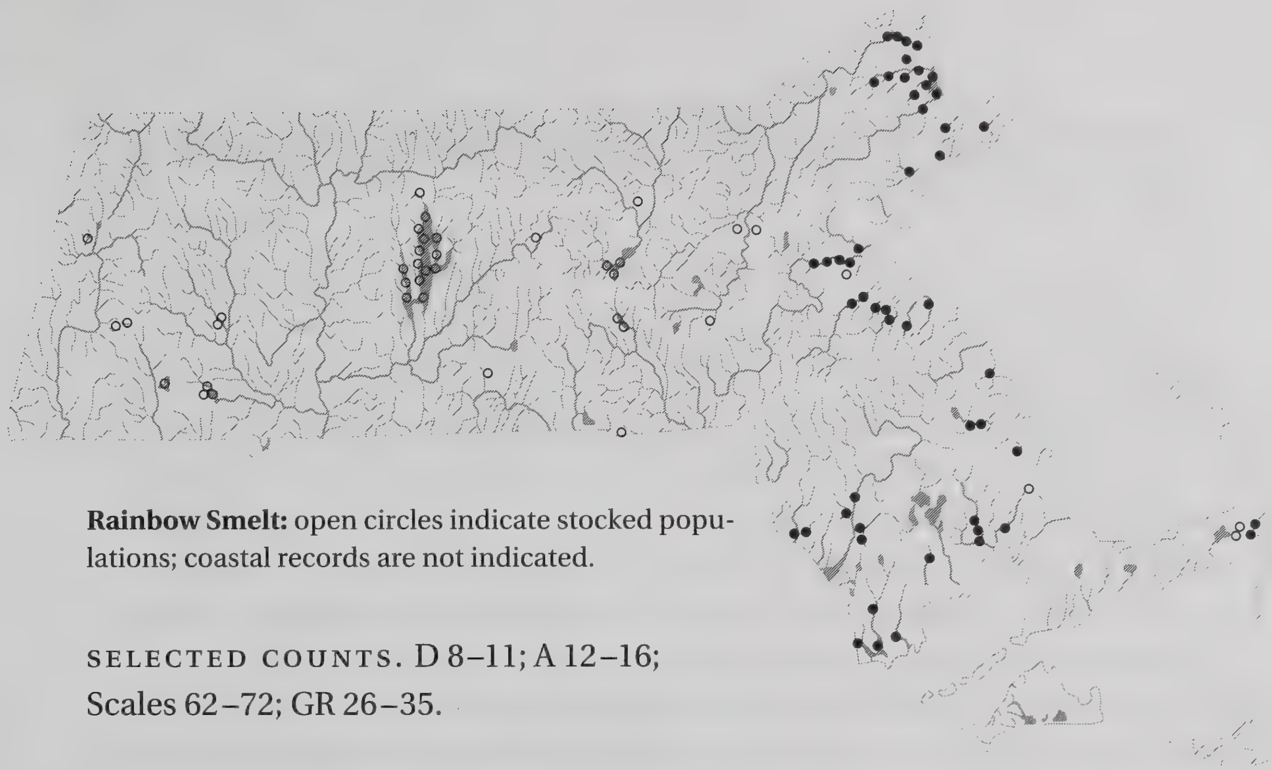
Native

Osmerus mordax (Mitchill 1814)

PLATE 43



IDENTIFICATION. Rainbow Smelt have adipose fins, a slender body, fangs on the tongue, relatively large scales (62 to 72 in lateral series), and a long lower jaw that reaches to the rear edge of the eye. They lack a well-developed pelvic axillary process (see family key Figure 17a, page 56). Smelt are silvery; the dorsolateral body is transparent olive-green with an iridescent blue to purple sheen.



Rainbow Smelt: open circles indicate stocked populations; coastal records are not indicated.

SELECTED COUNTS. D 8–11; A 12–16; Scales 62–72; GR 26–35.

SIZE. Most Rainbow Smelt are 7 to 9 inches TL, but occasional specimens may reach 13 to 14 inches TL.

NATURAL HISTORY. Anadromous Rainbow Smelt enter the lower edge of freshwater to spawn. Unlike salmon, smelt do not pass over dams or stream obstructions more than 2 feet high. Smelt spend much of the warmer months offshore but apparently never more than three miles from the shoreline. During the autumn, adults move back into the estuaries in preparation for their spawning migration. In the streams south of Cape Cod, this takes place in late February, but in the Gulf of Maine, the runs do not start until mid-March. Older, larger fish enter the spawning run first when water temperatures reach 39° to 43°F. Spawning is nocturnal, with peaks of spawning activity possibly coinciding with bimonthly spring tides. Spawning habitat is characterized by gravel and boulder substrate and relatively fast-flowing water. Each night, males swim upriver to the spawning sites, which are generally in areas where the water velocity is highest. Females can produce 7,000 to 45,000 eggs depending on body size. Smelt do not build nests; eggs and sperm are broadcast in the water column over a wide area by the flowing water. The fertilized eggs attach to the substrate or to vegetation and hatch in 11 to 31 days, depending on the water temperature. Most of the eggs hatch at night, and the young are swept into the estuary where they remain for the first year and grow to a total length of 2 to 5 inches. Voracious predators, the smelt feed on crustaceans, insects, worms, and

small fishes. Adult smelt are often taken by salmon, trout, Striped Bass, Bluefish, birds, and harbor seals.

DISTRIBUTION AND ABUNDANCE. Historically, Massachusetts Rainbow Smelt likely entered almost any unobstructed stream to spawn, but their distribution and abundance has been reduced since the turn of the century. D.H. Storer remarked that in the mid-1800s "750,000 dozen smelt" were taken annually with dip nets from the Charles River at Watertown. Smelt are still found in the lower Charles but, as in other streams, not in the numbers that Storer indicated. Smelt have been introduced into a number of inland lakes, ponds, and reservoirs as forage for trout and salmon. This practice started many years ago, when Frances Barnard (governor of the Bay Colonies, 1760–1769) made a successful introduction of smelt into Jamaica Pond, Boston. More recent introductions include the Quabbin, Wachusett, and Littleville reservoirs, Mattawa and Wallum lakes, and Big Alum, Cliff, Higgins, and Walden ponds. Spawning takes place in some of these waters. However, many inland populations appear to be declining, apparently due in part to the impacts of acid precipitation.

NOTES. Declines in anadromous smelt are primarily due to damming and siltation. Dams placed too close to the salt wedge may cause mass egg mortality due to high salinity and a fungus that results from overcrowding below the dams. Sport fisheries exist in many areas including the Neponset, Fore, Back, and Weir rivers that are tributaries to Boston Harbor. On the North Shore, runs are found in the Danvers, Saugus, Annisquam, Parker, Rowley, Essex, and Mill rivers. Large runs are also still found in the Jones and Weweantic rivers. However, none of these fisheries attracts the estimated 2,300 smelt fishermen as reported in Boston Harbor by Bigelow and Schroeder (1953).

REFERENCES. Bigelow and Schroeder 1953, Clayton et al. 1978 (MA marine); Murawski et al. 1980 (spawning, Parker River); Murawski and Cole 1978 (population, Parker River); Reback and DiCarlo 1972 (distribution); Storer 1840 (Jamaica Pond introduction).

Salmon, Char, and Trout Family

Salmonidae

The family Salmonidae contains about 70 recognized species and is divided into three groups: the salmon, trout, and chars (Salmoninae), the graylings (Thymallinae), and the whitefishes (Coregoninae), although the whitefishes are sometimes placed in their own family Coregonidae. The Salmoninae, the only members of this family found in Massachusetts, have soft-rayed fin supports, a dorsal adipose fin, an axillary process at the base of the pelvic fins, and a maxilla bone that forms most of the margin of the upper jaw. They also have over 100 fine scales in the lateral-line series, well-developed teeth on the jaws, and other head bones.

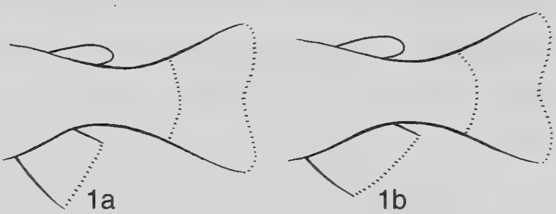
Since 1875, attempts have been made to introduce or translocate at least ten species of salmonids in Massachusetts, with only the exotic Brown Trout, Rainbow Trout, and Lake Trout now well established. With the exception of the Rainbow Trout, none of the other Pacific salmon, genus *Oncorhynchus,* has met with much success. There are reports of limited reproduction of Sockeye "kokanee" Salmon, *O. nerka,* in Laurel Lake, Lee, and Lake Onota, Pittsfield, and there may be a few nonreproducing individuals of Coho Salmon, *O. kisutch,* in the North River from stocking efforts between 1968 and 1987 that resulted in limited, but documented, reproduction and smolting.

All salmonids reproduce in freshwater and need cold, highly oxygenated water, minimal levels of pollution, and silt-free rocky or gravel substrate for successful spawning. Reproduction in salmonids is quite similar among most species. During spawning, males develop a hooked lower jaw. Ripe females select nest sites, usually on gravel-bottomed riffles, and a male defends the area and stays in close contact with the female. A nest (redd) is dug by the female by flapping vigorously with her caudal fin. After nest building is complete, the female is joined by the male, and eggs and sperm are deposited on the nest and covered with gravel. This process is repeated several times over a period of a week or more, and each female may spawn with several different males. The eggs remain buried over the winter (in fall-spawning species), and hatching occurs from early to late spring. The young remain buried in the gravel, absorbing the yolk sac, before emerging. Juvenile trout and salmon, called "parr," have a distinctive series of dark

blotches along their sides. The blotches, called "parr marks," disappear as the fish grows.

REFERENCES. Lauder and Liem 1983, Smith and Stearley 1989, Sanford 1990 (relationships); Maitland et al. 1981 (conservation); Balon 1980 (review, char); Garman 1895, Cardoza et al. 1993 (introductions); Hearn 1987 (competition); Halliwell 1989 (local habitat and distribution).

Key to Adult Massachusetts Salmon, Chars, and Trout



1a. Usually fewer than 12 anal rays (rarely 12), length of the fin base shorter than longest ray. Go to 2.

1b. Usually more than 13 anal rays (rarely 12 or 13), length of the fin base longer than longest ray. Typical Pacific salmon (Coho, Chinook), *Oncorhynchus.* See family account.

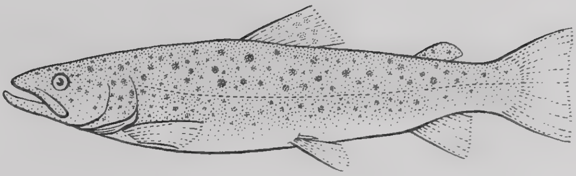
2a. Black spots on head and body; pelvic and anal fins lacking a white leading edge; head and shaft of vomer (midline bone in roof of mouth) fully toothed. Go to 3.

2b. Light spots, usually pink, red, or yellowish but not black, on head or body; leading edge of pelvic and anal fins pure white; teeth on head of vomer only. Go to 5.

3a. Caudal fin with radiating rows of black spots; red spots never present on body; adipose fin with black margin. Rainbow Trout, *Oncorhynchus mykiss,* page 174.

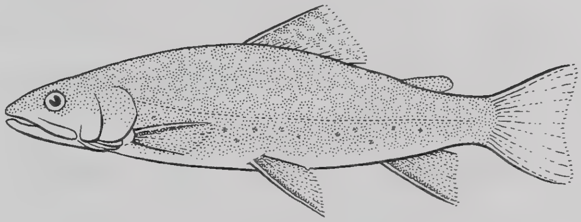
3b. Caudal fin usually unspotted, lacking radiating rows of black spots; reddish spots sometimes present on body; adipose fin lacking black margin (not illustrated). Go to 4.

4a. Gill cover usually with several small spots; end of jaw reaching last half of eye in small fish and beyond the eye in large fish; caudal fin broad and usually not forked; vomerine teeth well developed. Brown Trout, *Salmo trutta,* page 179, Plate 41.

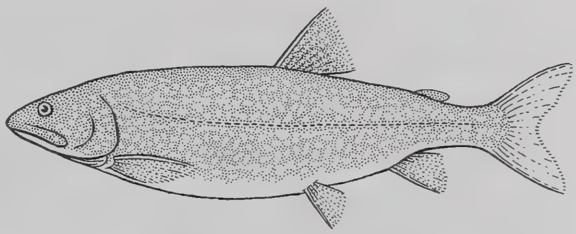


4b. Gill cover usually with 2 to 3 large spots; end of jaw seldom reaching past center of eye, except in large males; caudal fin shallowly forked; vomerine teeth not well developed. Atlantic Salmon, *Salmo salar,* page 176, Plate 40.

5a. Caudal fin weakly forked; body with red and white spots; pelvic and anal fins with white leading edge followed by a contrasting black stripe. Brook Trout, *Salvelinus fontinalis,* page 181, Plate 42.



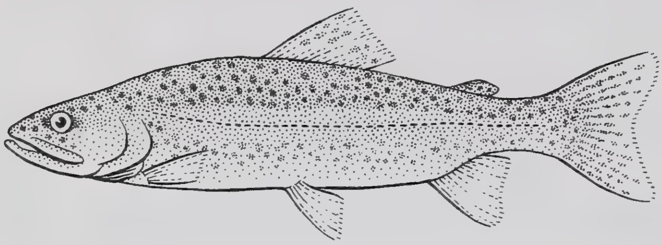
5b. Caudal fin strongly forked; sides with silver-gray spots; red spots lacking; anterior edge of pelvic and anal fins not followed by a contrasting black stripe. Lake Trout, *Salvelinus namaycush,* page 183.



Rainbow Trout

Introduced

Oncorhynchus mykiss (Walbaum 1792)

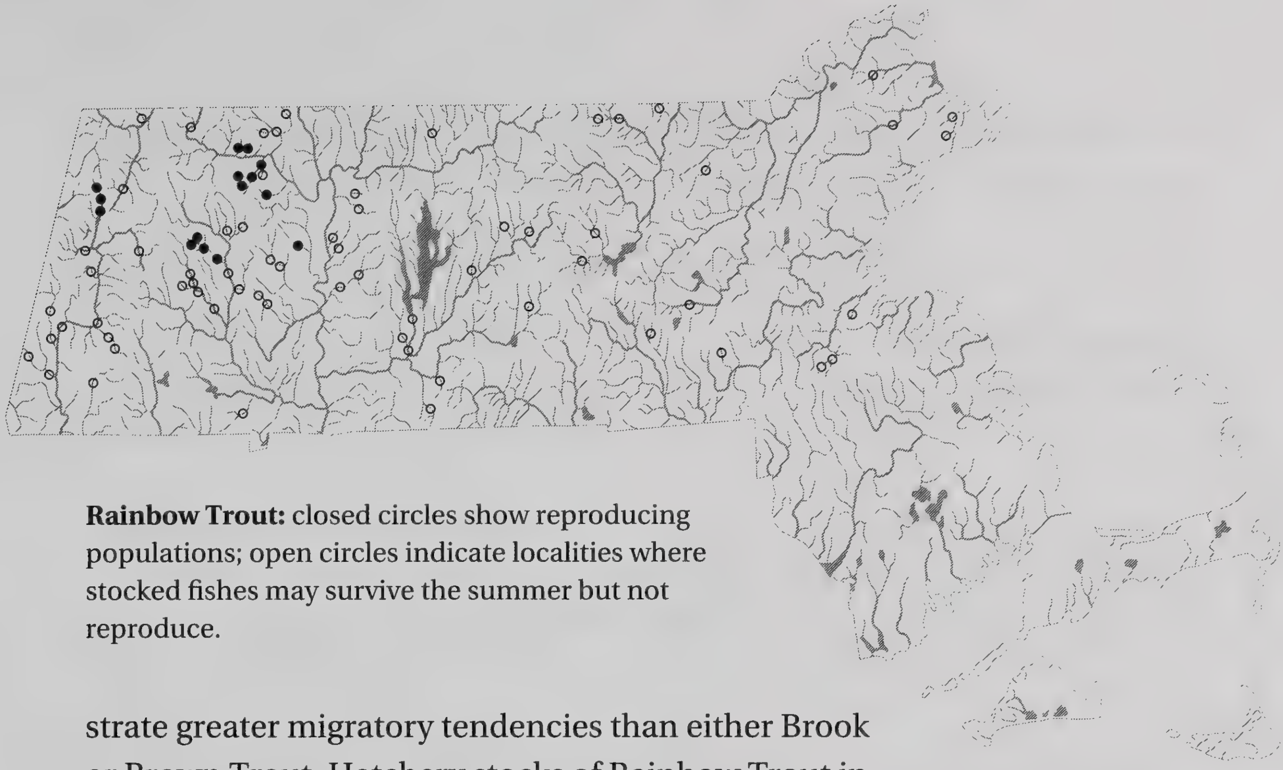


IDENTIFICATION. Rainbow Trout can be distinguished from the other local salmonids by the presence of many small dark or black spots on the caudal fin. Adults have a broad pink or red band along their sides and lack vermiculations on the back. Juveniles have an olive adipose fin with a black margin that is sometimes spotted and a series of 9 to 13 dark parr marks along each side.

SELECTED COUNTS. D 10–13; A 8–12; Scales 100–150; GR 15–16.

SIZE. Most large Rainbow Trout caught by anglers in Massachusetts streams originate from hatchery stocks that average 9 to 12 inches TL when released in the spring. Rainbow Trout ranging from 12 to 15 inches TL are also stocked in suitable ponds and lakes statewide, and they may grow to 5 to 6 pounds. The current state record is a 13.3-pound fish taken at John's Pond on Cape Cod in 1993.

NATURAL HISTORY. Rainbow Trout are the only spring-spawning salmonids reproducing in Massachusetts streams. The spawning period extends from March to May, coincident with rising water temperature. This species' feeding habits, spawning requirements, size, and growth are similar to those of native Brook Trout and introduced Brown Trout. Rainbow Trout prefer water temperatures between 65° and 68°F. Their distribution in Massachusetts may be limited by their relative intolerance to acidic waters. Reproducing populations in Massachusetts streams are restricted to cold-water streams with a high gradient (more than 75 feet per mile). In these streams, they prefer swifter currents, feed more during the day, and are not as secretive as Brown Trout. Rainbow Trout, particularly hatchery stock, demon-



Rainbow Trout: closed circles show reproducing populations; open circles indicate localities where stocked fishes may survive the summer but not reproduce.

strate greater migratory tendencies than either Brook or Brown Trout. Hatchery stocks of Rainbow Trout in streams and rivers usually do not hold over, as evidenced by their low recovery rate during summer stream survey work. However, Rainbow Trout may hold over in lakes with sufficient cold-water habitat.

DISTRIBUTION AND ABUNDANCE. Rainbow Trout are native to most of the Pacific drainages of western North America and are also found in parts of Siberia. They were first introduced into Massachusetts in 1883 and were stocked as fingerlings until the 1940s. Today, catchable-sized fish are stocked statewide. Reproducing populations of Rainbow Trout are restricted to a dozen or so streams in the Connecticut, Deerfield, Westfield, and Housatonic river drainages. In Massachusetts, coexisting and reproducing populations of Brook, Brown, and Rainbow Trout occur only in a single tributary to the Housatonic River in Lanesborough.

NOTES. Rainbow Trout were formerly treated under the species, *Salmo gairdneri,* which erroneously indicated a relationship with the Atlantic salmon group. Recently, the North American Rainbow Trout has also been shown to be the same species as the Rainbow Trout of the Kamchatka Peninsula in Siberia. Thus, it was necessary to change the specific name to *mykiss.* Later it was documented that the Rainbow Trout are more closely related to the Pacific genus *Oncorhynchus* than to the Atlantic genus *Salmo* so that now the American Fisheries Society recommends the use of *Oncorhynchus mykiss* as the correct name.

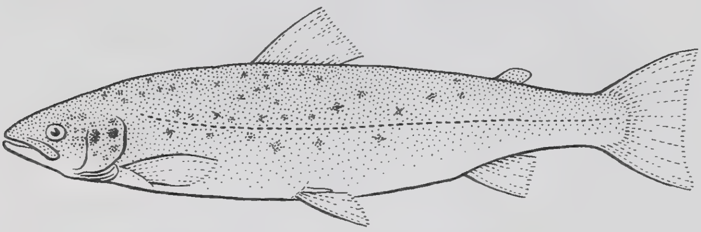
REFERENCES. Smith and Stearley 1989 (taxonomy); Halliwell 1989 (distribution, habitat, MA); Simmons 1997 (summer trout).

Atlantic Salmon

Native stocks extirpated

Salmo salar Linnaeus 1758

PLATE 40

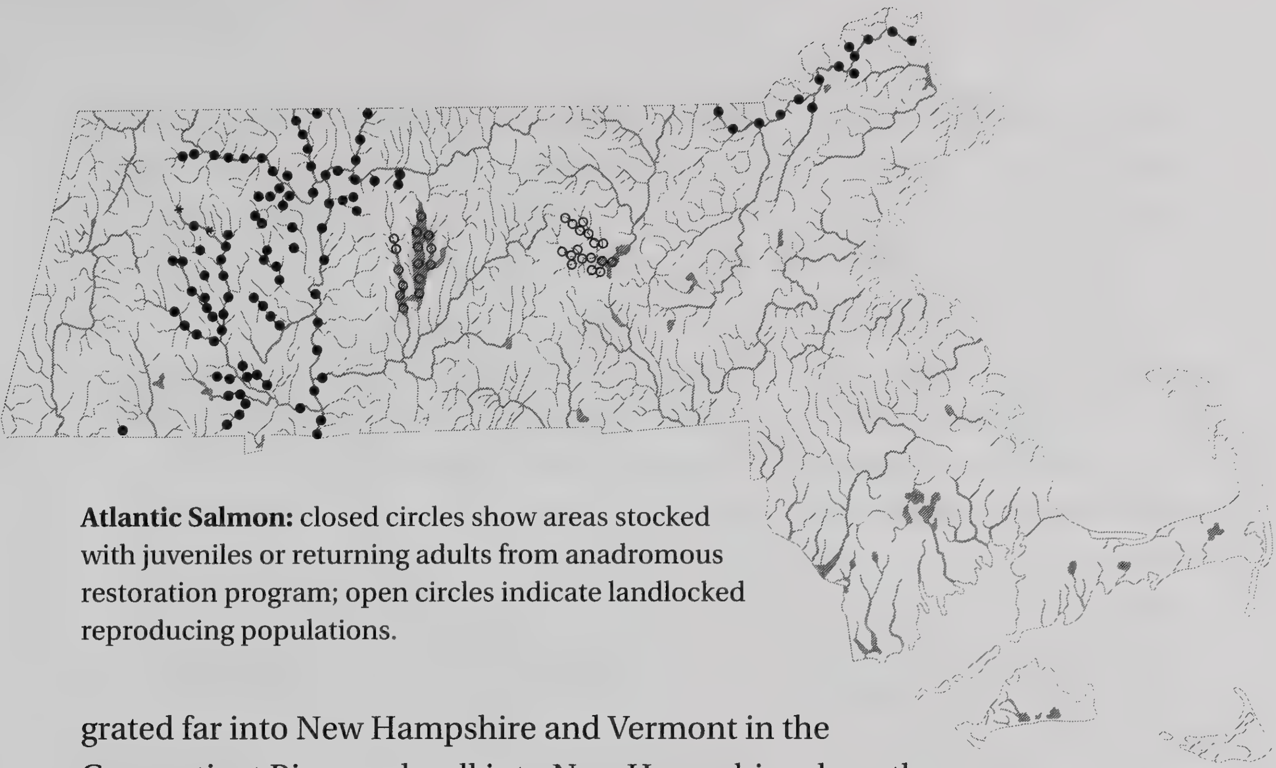


IDENTIFICATION. Atlantic Salmon and the related Brown Trout have teeth on the head and shaft of the vomer. Adult Atlantic Salmon have poorly developed deciduous teeth on the shaft of the vomer (well developed in Brown Trout) and small X-shaped spots on the body. Atlantic Salmon also have a smaller mouth, a more deeply-forked tail, and longer pectoral fins. They can be distinguished from the members of the Pacific salmon genus *Oncorhynchus* by the lack of black spots on the caudal fin. Juvenile Atlantic Salmon (parr) have 8 to 11 narrow parr marks with a single red spot between each pair of parr marks.

SELECTED COUNTS. D 10–13; A 8–11; Scales 110–120; GR 15–19.

SIZE. The average size of anadromous and landlocked Atlantic Salmon differs, with landlocked populations usually reaching only 20 inches TL. Anadromous forms commonly reach 30 inches TL. In anadromous forms, ocean growth is rapid and maximum size is larger; males returning after one year at sea weigh 3 to 6 pounds, fish returning after two years range from 6 to 12 pounds. Repeat spawners may weigh up to 40 pounds. In contrast, landlocked salmon average 2 to 4 pounds. The Massachusetts state record landlocked Atlantic Salmon, angled from Wachusett Reservoir in 1985, weighed 10 pounds, 2 ounces.

NATURAL HISTORY. Anadromous Atlantic Salmon spawn in freshwater streams and then return to the sea. Historic accounts show that they mi-



Atlantic Salmon: closed circles show areas stocked with juveniles or returning adults from anadromous restoration program; open circles indicate landlocked reproducing populations.

grated far into New Hampshire and Vermont in the Connecticut River and well into New Hampshire along the Merrimack River. Young salmon remain in freshwater for two to three years, descending to the sea as "smolts" when they reach 5 to 9 inches TL. At sea, they live for one or two more years before returning to their natal streams to spawn. Although spawning occurs from October through November, most adults return to freshwater well before then, typically in May and June (see family account for general spawning habits and requirements). Unlike most Pacific salmon, which die after spawning, many post-spawning Atlantic Salmon survive and return to the sea. Food habits vary with life stages. At sea, salmon eat a variety of marine organisms, including crustaceans and smaller fishes. Despite their willingness to accept an angler's fly, adult Atlantic Salmon do not feed in freshwater prior to spawning. Young Atlantic Salmon feed primarily on aquatic and terrestrial insects while they are in freshwater. Landlocked Atlantic Salmon in large Massachusetts reservoirs feed principally on introduced Rainbow Smelt, young White Perch, and midges and ants (J. Bergin 1998, pers. comm.).

DISTRIBUTION AND ABUNDANCE. In Massachusetts, native anadromous Atlantic Salmon were historically known from the Connecticut and Merrimack rivers. Populations may also have been present in other suitable rivers before they were overfished or dammed, but there is little information that is not anecdotal. Early accounts mention their great abundance, particularly in the Merrimack, where 60 to 100 were taken daily near the river mouth in 1790. The Connecticut River had a large run until dams constructed at

Hadley (1794) and Turners Falls (1798) eliminated the upstream salmon run in as little as 12 years. Additional dam construction at Lawrence on the Merrimack River in 1847 destroyed one of the finest Atlantic Salmon runs in New England. Stolte (1981) estimated that the historic population in the Merrimack Drainage possibly ranged from 8,940 to 26,820 adults.

For many years, ongoing attempts to restore Atlantic Salmon to Massachusetts rivers have had limited success due to a combination of many factors, including poorly designed fishways, inferior genetic stock, turbine mortality, and poor survival rates at sea. Following the release of millions of fry and smolts over a 20-year period, the first redds and eggs of Atlantic Salmon were found in the main stem of the Westfield River by biologists J. O'Leary and D. Pugh in November 1994. Since then, a few additional redds have been found in upper tributaries to the Westfield River. Landlocked Atlantic Salmon have been introduced into the Quabbin, Wachusett, and Littleville reservoirs. These landlocked forms, originating from lakes in Maine and New Hampshire, are genetically similar to anadromous Atlantic Salmon but differ primarily in their nonmigratory habits and their ability to live in deep lake environments.

NOTES. Landlocked salmon were first introduced into Quabbin Reservoir in May 1965, with 14,400 spring yearlings from Maine. Most of the adult anadromous Atlantic Salmon that are now captured at fish lifts at the Holyoke Dam on the Connecticut River and the Lawrence Dam on the Merrimack River from May to June were stocked as yearlings (Figure 3). Most of these adult salmon are captured and artificially spawned under hatchery conditions, and their young are released into selected tributaries during the following spring.

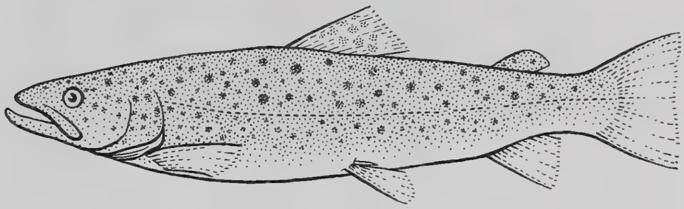
REFERENCES. Bridges and Hambly 1971, Bergin 1996 (Quabbin Res.); Sochasky 1981, Lacroix et al. 1985 (impacts of acidification); Rosseland and Skogheim 1984, White et al. 1984 (acid mitigation); Gibson 1973, Symons 1974, Kennedy and Strange 1980, Hearn 1987 (competition); Saunders 1981 (management); Behnke 1972, 1986, 1988 (taxonomy); Kendall 1935; Dymond 1963 (biology, historic records); Stolte, 1981 (Merrimack population); Rideout 1989, Rideout and Stolte 1988, Foster 1991, O'Leary 1995 (restoration).

Brown Trout

Introduced

Salmo trutta Linnaeus 1758

PLATE 41

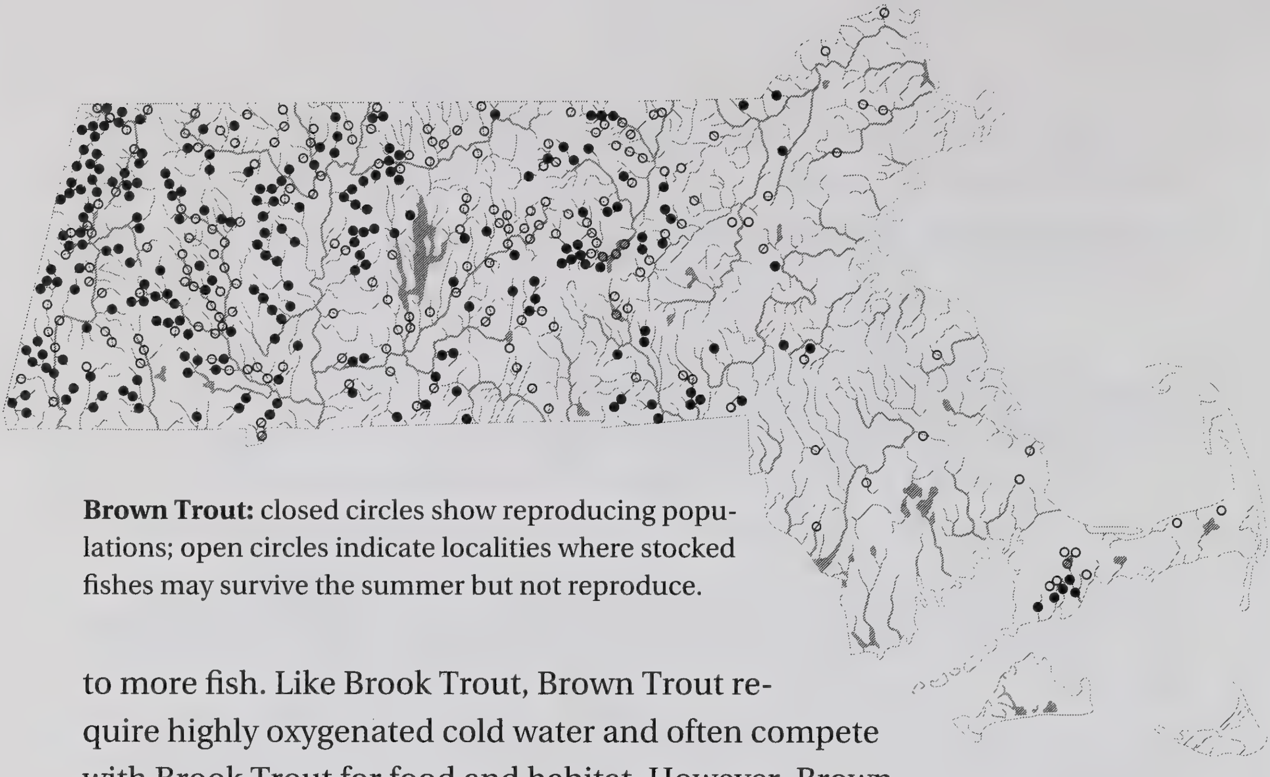


IDENTIFICATION. Brown Trout and the related Atlantic Salmon have well-developed teeth on both the head and on the shaft of the vomer, the bone along the midline of the roof of the mouth. Brown Trout have a large mouth that reaches well beyond the eye in large fish (to about mideye in 6-inch fish) and usually have an almost square tail. The sides, back, and dorsal fin have dark brown-black spots, often framed in a halo of blue. Red-orange spots are often found on the adipose fin and sides, usually below the lateral line. They lack white edges on the pelvic and anal fins and black spots on the caudal fin, and generally lack the Atlantic Salmon's X-shaped markings on the sides.

SELECTED COUNTS. D 10–14; A 8–12; Scales 120–130; GR 14–18.

SIZE. Massachusetts Brown Trout typically range from 8 to 10 inches TL, although older fish often grow to 15 inches TL. Brown Trout inhabiting cold-water ponds and lakes, as well as coastal "sea-run" populations, grow larger and weigh up to 10 pounds. The current state record for Brown Trout, a 19-pound, 10-ounce fish, was taken in 1966 from Wachusett Reservoir.

NATURAL HISTORY. Brown Trout spawn from late autumn to early winter (October to December) in tributary streams and small rivers. They prefer spawning substrate with stones ranging from 0.25 to 3 inches in diameter. Larger females tend to select areas with larger stones. Stream populations of Massachusetts Brown Trout generally live longer and grow faster than Brook Trout. Most stream-dwelling Brown Trout mature at the end of their second year of life and generally live for at least three growing seasons. They rarely live more than five years in the wild. Juvenile Brown Trout are primarily insectivorous, but as they approach 8 to 12 inches TL, their diet shifts



Brown Trout: closed circles show reproducing populations; open circles indicate localities where stocked fishes may survive the summer but not reproduce.

to more fish. Like Brook Trout, Brown Trout require highly oxygenated cold water and often compete with Brook Trout for food and habitat. However, Brown Trout can tolerate higher water temperatures than Brook Trout. In cold-water habitats, the largest Brown Trout are found in lower stream reaches where cover and large, deep pools are found.

DISTRIBUTION AND ABUNDANCE. Brown Trout, natives of Europe and western Asia, were first introduced into Massachusetts in 1887. Original stocks included both the German Brown strain from central Europe and the Loch Leven strain from Scotland. Today, reproducing Brown Trout occur in most cold-water streams of the Berkshire Valley and Central Uplands of Massachusetts, but they are only sporadically found farther east. Sea-run populations are reported from a few of the larger streams in the Falmouth-Mashpee area of Cape Cod. Aside from stream gradient and temperature, a major factor limiting the distribution of Brown Trout in Massachusetts is acidification. Brown Trout will not thrive in areas that do not have the capacity to naturally buffer acids.

NOTES. The first Massachusetts stocking policies limited the introduction of Brown Trout to waters where they would not compete with the native Brook Trout. However, the issue of competition between the two species was forgotten, and Brown Trout were introduced into areas with established Brook Trout populations. The original stocking policies for Brown Trout were valid, because Brown Trout can negatively influence Brook Trout populations. Consequently, we believe new introductions of Brown

Trout should not be made where native populations of Brook Trout exist in the absence of Brown Trout.

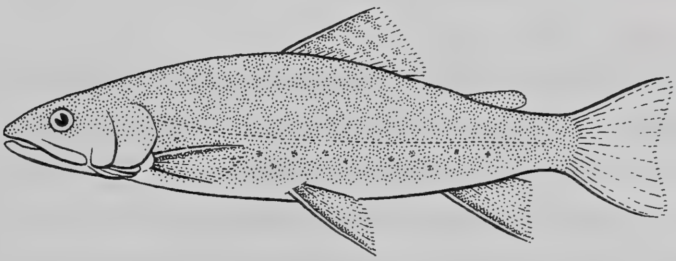
REFERENCES. Belding 1920 (introduction, MA); MacCrimmon and Marshall 1968 (worldwide distribution); Fausch and White 1981, Hearn 1987 (competition); Bachman 1984 (foraging behavior); Horton 1961, McFadden and Cooper 1962 (population ecology); Bergin 1984 (sea-run stock management); Halliwell 1989, Simmons 1997 (distribution and macrohabitat, MA).

Brook Trout or Brook Char

Native

Salvelinus fontinalis (Mitchill 1814)

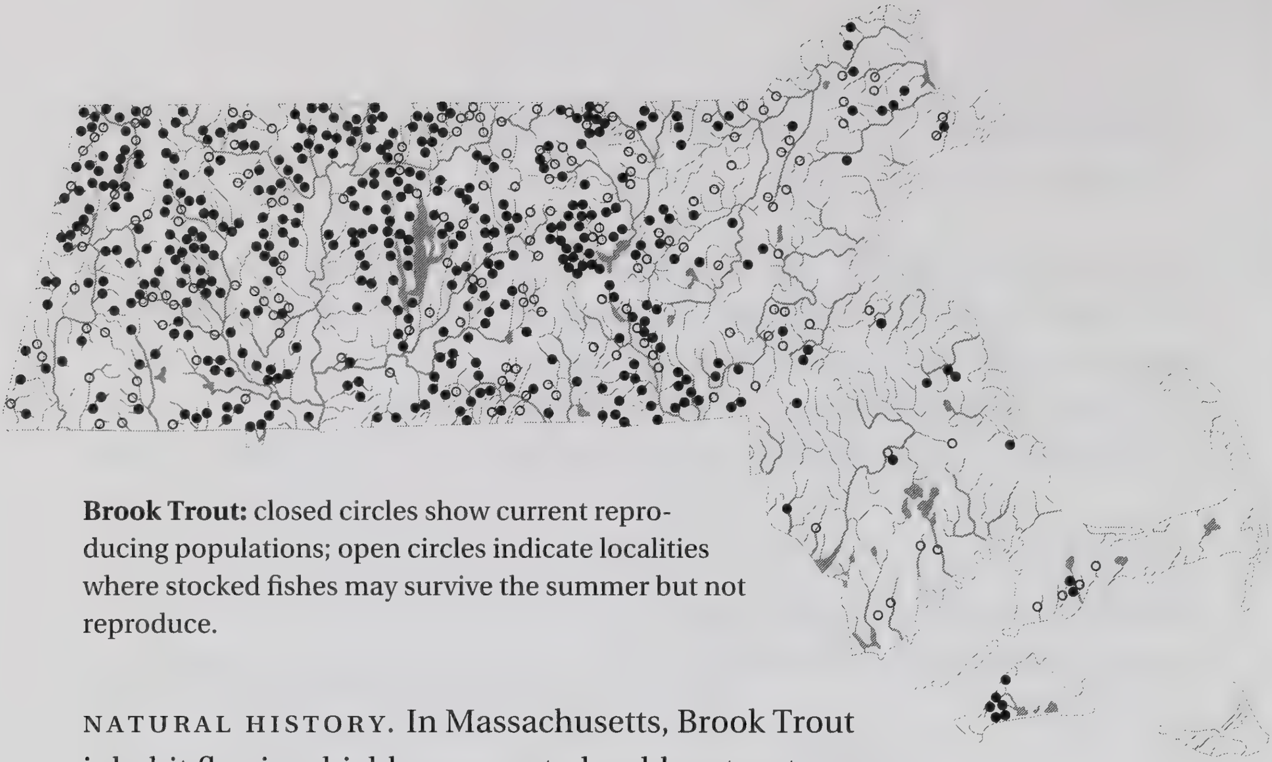
PLATE 42



IDENTIFICATION. The chars (Brook and Lake Trout) lack teeth on the shaft of the vomer and black spots on the body. Brook Trout have heavy dorsal vermiculations (worm-like markings) and a dark stripe behind the white leading edges of the pelvic and anal fins. In addition, they have a squarish or shallowly forked tail and red spots, often with blue halos, along the sides. Colors intensify during spawning and the lower flanks and belly of males become deep magenta.

SELECTED COUNTS. D 10–14; A 8–13; Scales 110–130; GR 14–22.

SIZE. Adult Brook Trout in Massachusetts streams reach 6 to 8 inches TL, but total lengths of 10 to 12 inches are possible in unexploited populations. One- or two-year-old fish ranging from 3 to 6 inches TL are most numerous in stream populations. Brook Trout living in cold-water ponds and lakes and the coastal salter populations (a sea-run form) grow considerably larger and faster. The current state record for a Brook Trout is 6 pounds, 4 ounces; it was caught in 1968 from Otis Reservoir in western Massachusetts.



Brook Trout: closed circles show current reproducing populations; open circles indicate localities where stocked fishes may survive the summer but not reproduce.

NATURAL HISTORY. In Massachusetts, Brook Trout inhabit flowing, highly oxygenated, cold-water streams. They tolerate a variety of habitats, from high-gradient mountain streams to low-gradient meadow brooks generally kept cool by groundwater or springs. The sea-run form, or salter, has a life cycle similar to that of the Atlantic Salmon, with adults spending part of their lives in salt water. Brook Trout have more rigid temperature requirements than do Brown Trout, Rainbow Trout, or Atlantic Salmon. They generally do not tolerate water temperatures exceeding 68°F for extended periods of time. Studies in Massachusetts indicate that the optimum range for maximum activity and feeding is between 55° and 65°F. Brook Trout spawn in both lakes and streams, although lake-spawning populations are rare in Massachusetts. Spawning lasts from late September through November, but elevation and water temperature influence the exact timing. Stream populations spawn over gravel riffles composed of coarse sand or stones up to 4 inches in diameter. Individuals mature at an early age, and some males capable of spawning during their first year are between 3.5 and 4 inches, although most males mature during their second year. The life span of Brook Trout in Massachusetts streams seldom exceeds three growing seasons. Stream Brook Trout are insectivorous throughout their lives. Pond-dwelling and salter Brook Trout populations tend to consume fish in addition to invertebrates.

DISTRIBUTION AND ABUNDANCE. Reproducing Brook Trout are found all across Massachusetts. Due to widespread introductions, native populations are difficult to distinguish from stocked populations. Brook Trout are

most common in western and central Massachusetts and occur only sporadically in the east. The eastern populations have declined, and today only a few geographically isolated populations remain. Likewise, salter Brook Trout that were historically found in one or two tributaries to Massachusetts Bay have been extirpated. Salters, though reduced in numbers, are still known from a few tributaries to Nantucket Sound, as well as Buzzards and Narragansett bays, but these populations have not been studied critically.

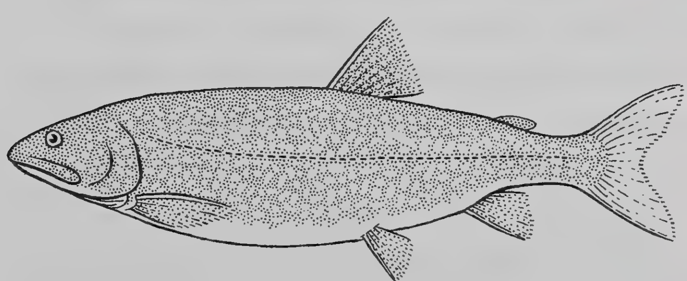
NOTES. The remnant Brook Trout populations in eastern Massachusetts are indicators of the location of relatively undisturbed environments. Their continued presence serves as a barometer for measuring the condition of the environment for the trout and other organisms that require cold clean water.

REFERENCES. Bridges and Mullen 1972 (life history, MA); Bigelow 1963 (review); Power 1980 (life history); Behnke 1980 (taxonomy); Estes 1987 (bibliography); Mullan 1958, Ryther 1997 (sea-run, MA); Halliwell 1989 (MA distribution, habitat); Wydoski and Cooper 1966 (growth); McFadden 1961 (population); Daye and Garside 1975, 1976 (acid conditions); Hearn 1987 (competition).

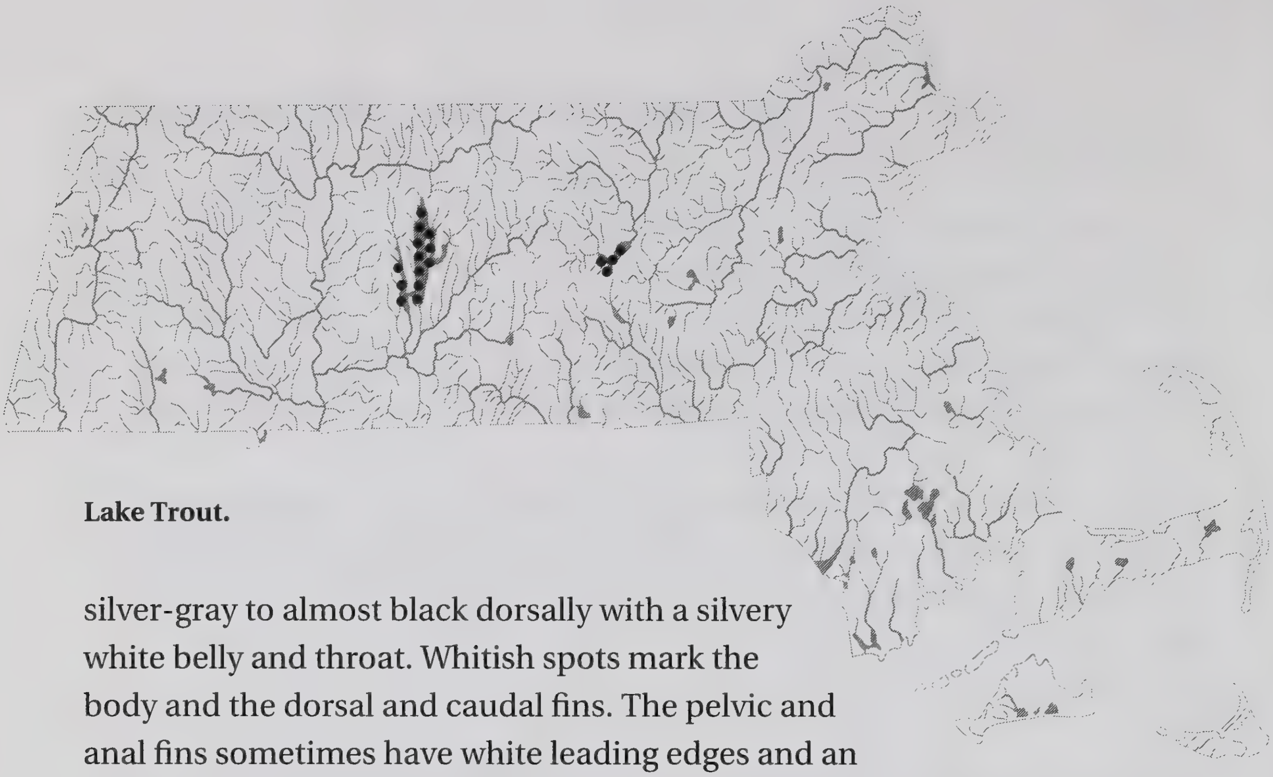
Lake Trout or Lake Char

Introduced

Salvelinus namaycush (Walbaum 1792)



IDENTIFICATION. The chars (Lake and Brook Trout) lack black spots on the body and teeth on the shaft of the vomer. Lake Trout have a more streamlined body and a distinctly forked tail and lack the red spots found on the sides of Brook Trout. In addition, Lake Trout have more than 92 pyloric caeca while Brook Trout have fewer than 56. Body color ranges from



Lake Trout.

silver-gray to almost black dorsally with a silvery white belly and throat. Whitish spots mark the body and the dorsal and caudal fins. The pelvic and anal fins sometimes have white leading edges and an orange wash, but the markings are not as conspicuous as in Brook Trout.

SELECTED COUNTS. D 8–11; A 8–10; Scales 116–138; GR 16–26.

SIZE. The Lake Trout is the largest North American char. Adult Massachusetts Lake Trout average 18 to 27 inches TL and 2 to 8 pounds, respectively. The current Massachusetts record, weighing 22 pounds, 10 ounces and measuring 38 inches TL, was taken at Quabbin Reservoir in 1988.

NATURAL HISTORY. Lake Trout require large, deep, cold-water lakes; in Massachusetts, they are confined to built reservoirs. During the summer, adult Lake Trout inhabit depths of 60 to 130 feet and prefer a constant water temperature of 55°F. In late fall, winter, and spring, Lake Trout move into shallow waters. In Massachusetts, Lake Trout spawn during October and November at depths of 10 to 75 feet, over rubble, riprap, or rock substrates. Two strains, a shallow-water, shoal-spawning form and a deep-water-spawning form, are suspected to exist in Massachusetts. Male Lake Trout usually do not spawn until they are 14 to 17 inches TL and four to six years old. Females first spawn at 18 to 21 inches TL and six to eight years of age (J. Bergin 1998, pers. comm.). Individuals spawn over a two-week period from sunset to midnight. Males usually precede females to the spawning grounds, where they sweep away debris by fanning and rubbing the substrate. Following the arrival of females, spawning starts and the fertilized

eggs sink between rocks where they are left unattended. The eggs hatch from late February to April, and the young gradually move into deeper waters.

Lake Trout are long-lived and slow-growing fishes. In November 1970, a 27-inch male Lake Trout was tagged and released at Quabbin Reservoir; when it was recaptured in July 1985, it measured only 35 inches TL. For the first two years of life, Lake Trout feed primarily on small insects and zooplankton. By 12 to 15 inches TL, they are primarily piscivorous, feeding on almost any suitably sized fish found in their deep, cold-water habitats. In Massachusetts, they feed primarily on introduced Rainbow Smelt and, to a lesser extent, on White Perch, Yellow Perch, and isopods.

DISTRIBUTION AND ABUNDANCE. While there were some unsuccessful Massachusetts introductions of Lake Trout in the 1870s, the first recent introduction occurred in 1952 with stocks of fingerlings from the Lake Ontario region of New York. The later stocks (1965–1970) come from a Finger Lakes deepwater strain (Seneca-Cayuga Lakes). Lake Trout are found only in the Quabbin and Wachusett reservoirs. Both areas are characterized by deep, cold, well-oxygenated water.

REFERENCES. Martin and Oliver 1980 (life history); Behnke 1980, 1984 (taxonomy); Johnson et al. 1987 (acidification-bioassay); Bridges and Hambly 1971, Keller 1987 (Quabbin management); Marshall and Keleher 1970 (bibiliography 1929–1969); Daly et al. 1962 (life history); Martin and Baldwin 1960 (hybridization).

Trout-perch Family

Percopsidae

The Trout-perch family is characterized by an unusual combination of both primitive and advanced features. An adipose fin is present, as in trout and catfishes, and there are true fin spines, an advanced feature found, for example, in sunfishes and perch. This family has a relatively large and slightly subterminal mouth, a nonprotrusible upper jaw, small teeth, and ctenoid scales. Trout-perch are thought to be closely related to the Pirate Perch (Aphredoderidae) and the cavefishes (Amblyopsidae). The Percopsidae is a small group comprising a single genus and two species that are endemic to North America. One species is widely distributed in eastern and middle North America, while the other species is restricted to a portion of the Columbia River in the extreme northwestern United States. Trout-perch are generally small, usually less than 5 inches in length, and nocturnal. Where abundant, Trout-perch are an important forage fish for many of the larger game fish, including trout, Yellow Perch, and Northern Pike.

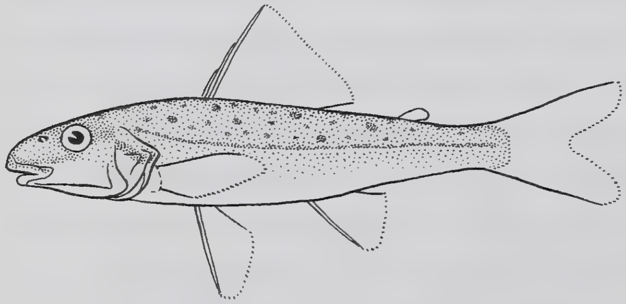
REFERENCES. Lauder and Liem 1983 (relationships); Scott and Crossman 1973 (general).

Trout-perch

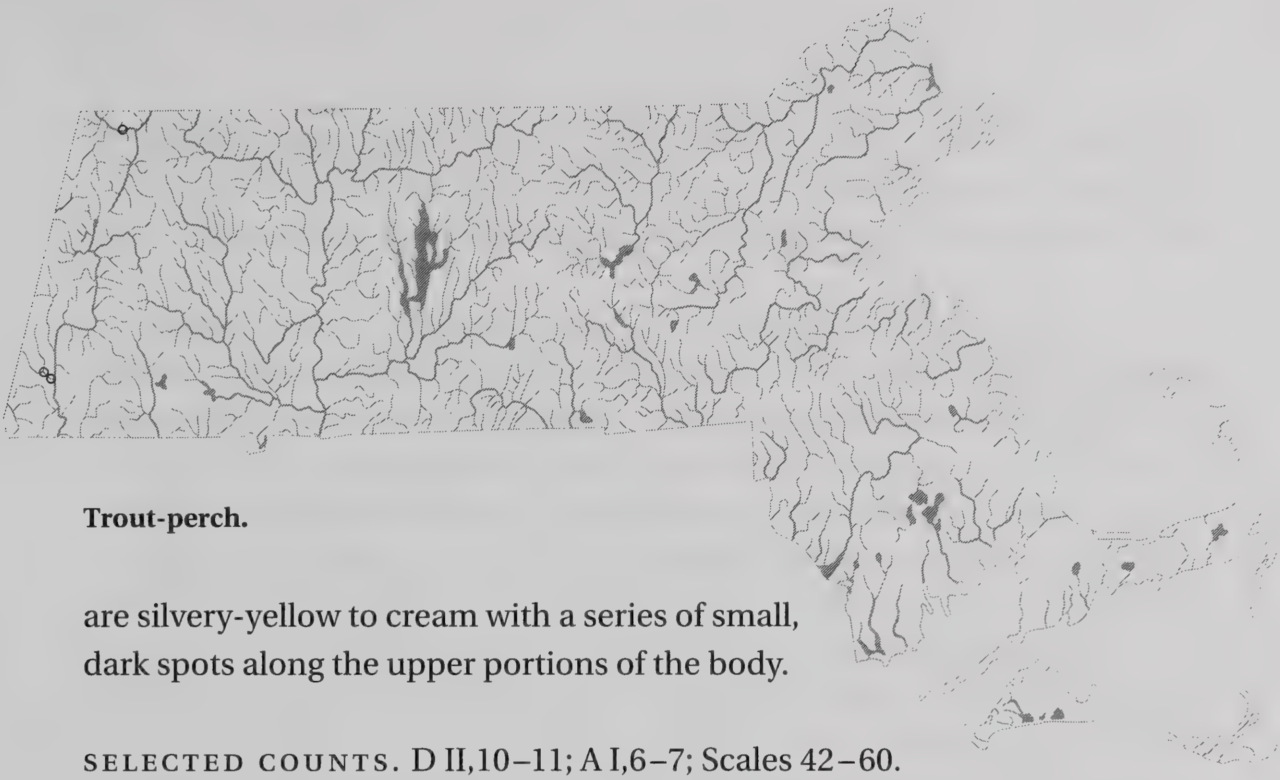
Native, State Extirpated

Percopsis omiscomaycus (Walbaum 1792)

PLATE 30



IDENTIFICATION. Trout-perch are distinguished from all other Massachusetts fishes because they have the combination of an adipose fin, true spines, a slightly subterminal mouth, ctenoid scales, and lack barbels. They



Trout-perch.

are silvery-yellow to cream with a series of small, dark spots along the upper portions of the body.

SELECTED COUNTS. D II,10–11; A I,6–7; Scales 42–60.

SIZE. Trout-perch are small fishes; most individuals are less than 5 inches TL.

NATURAL HISTORY. Trout-perch were last found in Massachusetts in the early 1940s. Information about their natural history in this state is unknown. In other parts of their range, Trout-perch are still common and have been extensively studied. They typically inhabit lakes and quiet, backwater pools in streams. Trout-perch stay in deep water or under cover during the day and become active at night. Their diet consists of a variety of small invertebrates, including mayflies, amphipods, midges, and, occasionally, small fishes. Spawning occurs from mid- to late spring in small, rocky tributary streams or in shallow, inshore areas of lakes. Females have been found to carry up to 750 eggs.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Trout-perch were known from only three localities in the extreme western portion of the state. The earliest record is based on a single specimen collected at Williamstown, Hoosic Drainage, prior to 1859. Six specimens were collected near the mouth of the Green River, Housatonic Drainage, between 1940 and 1942 (McCabe 1942), but these specimens have been lost. A second collection of 12 specimens from the Green River, a half-mile above the Housatonic River, was also made by B. McCabe, and they are now preserved at the Museum

of Comparative Zoology. The Trout-perch may never have been common in this state. Surveys between 1978 and 1990 have failed to locate this species, and it is now presumed to have been extirpated from Massachusetts.

NOTES. As Trout-perch are nocturnal and rather secretive, it is possible that populations still survive in Massachusetts. Surveys in the upper Hoosic Drainage in New York, downstream of Massachusetts, have found the Trout-perch to be common in the mid-1980s. But in the Housatonic Drainage in Connecticut, Trout-perch have not been collected since 1879 (Whitworth et al. 1968). Extensive pollution in the Hoosic and Housatonic drainages may have caused the decline of this species. Extirpation of the Trout-perch in Virginia is thought to be due to introduced predators coupled with other factors.

REFERENCES. Crowder et al. 1981 (diet); Kinney 1950 (life history); McCabe 1942 (first MA record); Magnuson and Smith 1963 (life history); Smith 1985 (NY records); Jenkins and Burkhead 1993 (VA).

Cod Family

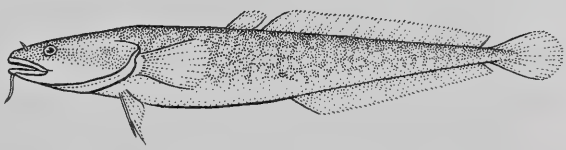
Gadidae

The cod family consists of about 30 species that are found primarily in the marine waters of the Northern Hemisphere. Cods belong to the order Gadiformes, a group that also contains such fishes as Pollack, hakes, whitings, haddock, cusk, and rocklings. The codfish order has been historically characterized in part by a specialized arrangement of the caudal vertebrae and caudal fin rays. However, the group's interrelationships are confusing due to many reduced or lost characters that are difficult to interpret. The Burbot, *Lota lota,* is sometimes placed in the family Lotidae or the subfamily Lotinae. Cods have one, two, or three dorsal fins plus one or two anal fins, and most species have a single, median chin barbel. Cods are among the world's most commercially important fish families, with about 12 million metric tons being taken worldwide each year.

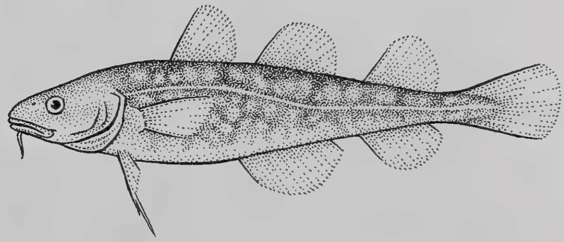
REFERENCES. Bigelow and Schroeder 1953 (marine species); Markle 1989, Patterson and Rosen 1989 (relationships); Fahay 1983, Dunn and Matarese 1984 (larvae, development and relationships); Jensen 1972 (cod fishery); Cohen 1989 (general).

Key to the Massachusetts Freshwater Cods

1a. Two dorsal fins; length of the base of the second 6 or more times the length of the first; one anal fin. Burbot, *Lota lota,* page 190, Plate 39.



1b. Three dorsal fins; bases of each of near equal lengths; 2 anal fins. Atlantic Tomcod, *Microgadus tomcod,* page 192, Plate 38.

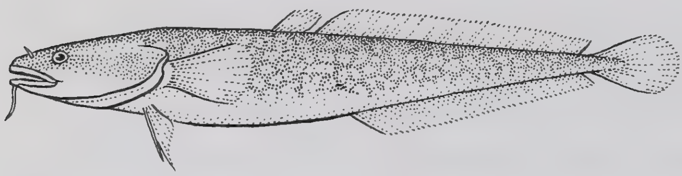


Burbot

Native, Special Concern

Lota lota (Linnaeus 1758)

PLATE 39



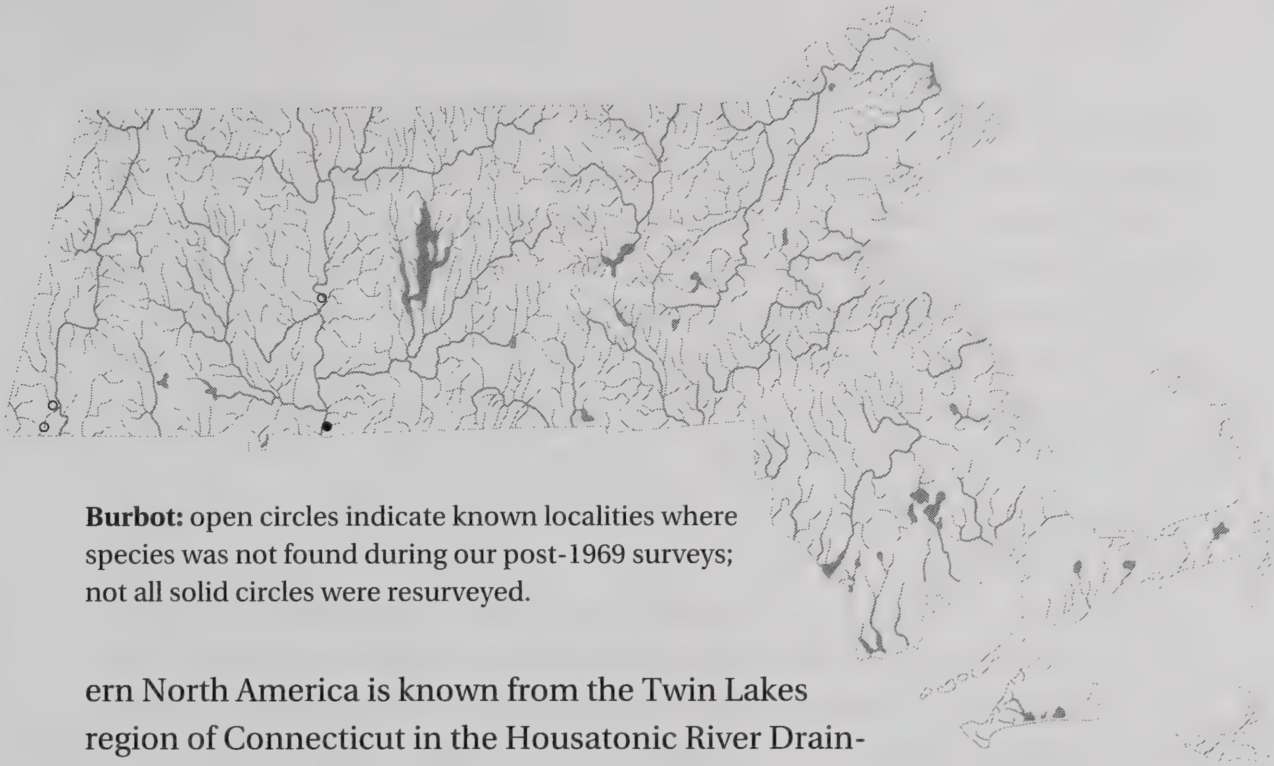
IDENTIFICATION. Burbot have a median chin-barbel, long second dorsal and anal fin, and an elongate body. They are the only member of the cod family restricted to freshwater. The upper body is light brown to gray and mottled with darker shades of brown and gray. The dorsal and caudal fins of young Burbot are usually edged with dark pigment, and a dark spot with a light ocellus is on the upper caudal fin.

SELECTED COUNTS. D 10–12, 66–67; A 65–71.

SIZE. Burbot may grow as large as 3 feet TL in some parts of their range. The largest specimens are usually found in large, deep lakes or rivers. Individuals living in smaller rivers and streams grow only to lengths of slightly over 12 inches TL.

NATURAL HISTORY. Little is known about Burbot in Massachusetts. In other areas, they are a resident of cold deepwater lakes and rivers. Burbot enter tributaries in late winter and spring and spawn nocturnally, under the ice, between November and March. They spawn in tight groups that resemble a ball of whirling fishes. Post-larvae, recently collected near the mouth of Longmeadow Brook, Longmeadow, were probably spawned in February. This species is largely nocturnal. During the daytime, juveniles can be found under large, flat rocks in a foot or so of water. Young Burbot feed on aquatic insects and crustaceans, but large adults feed almost exclusively on fishes. Their choice of prey depends on availability and sometimes includes Alewives, salmon, smelt, sculpins, and sticklebacks.

DISTRIBUTION AND ABUNDANCE. Burbot are distributed throughout the Northern Hemisphere. The southernmost population of Burbot in east-



Burbot: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

ern North America is known from the Twin Lakes region of Connecticut in the Housatonic River Drainage. In Massachusetts, Burbot are rare; to date, they are known from only a few records. Lesueur (1818) described and illustrated a juvenile specimen from Northampton (presumably from the Connecticut River). Storer (1839) stated that he saw a 6-inch fish from the Ashuelot River, New Hampshire (Connecticut Basin), but later (1867) he mentions another (or the same?) 6-inch specimen from the Connecticut River (in Massachusetts?). In July of 1970, J. Bergin and a Massachusetts Division of Fisheries and Wildlife survey crew found single specimens (7.5 and 8.5 inches TL) in Hubbard and Schenob brooks, both in the Housatonic Drainage, near the Connecticut state line. The most recent record is based on two post-larvae found on May 16, 1987, by W. Kenney, a Springfield aquarist, in Longmeadow Brook near the Connecticut River. One of the specimens (now in the MCZ collection) was raised until mid-June, when it measured about 1 inch TL (30 mm SL) and was definitely identified as a Burbot. The most recent records are a 1998 MDFW find of a 12-inch fish at the mouth of the Fort River, Hadley, and another 12-inch specimen brought to Douglas Smith at the University of Massachusetts by an angler who caught it in a pool below the Turners Falls dam on the Connecticut River in December, 2000. The angler noted that other specimens have been caught. This most recent record is not plotted on the distribution map.

NOTES. Due to the species' rarity, the Burbot is listed as a Species of Special Concern in Massachusetts, but its actual status is an enigma. Stream surveys attempting to locate Burbot in the Housatonic (1979–1989) and in the

Connecticut tributaries (1979–1988) failed to find the species. Burbot were never collected during hundreds of gillnet sets or seine hauls made over a 20-year period (1969–1989) by the Massachusetts Cooperative Fisheries Research Unit in the Connecticut River main stem. In addition, local anglers did not report this species until one was brought to our attention in December, 2000. Since some Burbot found at the southern edge of their range may be vagrants from established populations, it is possible that the Connecticut River fishes are from upriver in New Hampshire. If this is correct, the eggs, larvae, juveniles, or prespawning adults would have been washed at least 100 miles downstream and over at least three major dams. In contrast, it is also possible that there still exists a small population of Burbot in one of the deep pools along the Connecticut River or within its major tributaries. Whitworth (1996), with limited data, states that the species is introduced in the Connecticut and Housatonic drainages in Connecticut.

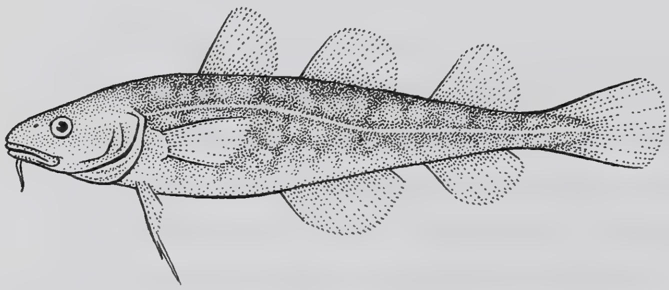
REFERENCES. Bergin 1970 (Housatonic records); Lesueur 1817 (first MA record); Scott and Crossman 1973, Lee and Gilbert 1980 (general); Storer 1839 (historical record); Whitworth (1996).

Atlantic Tomcod

Native

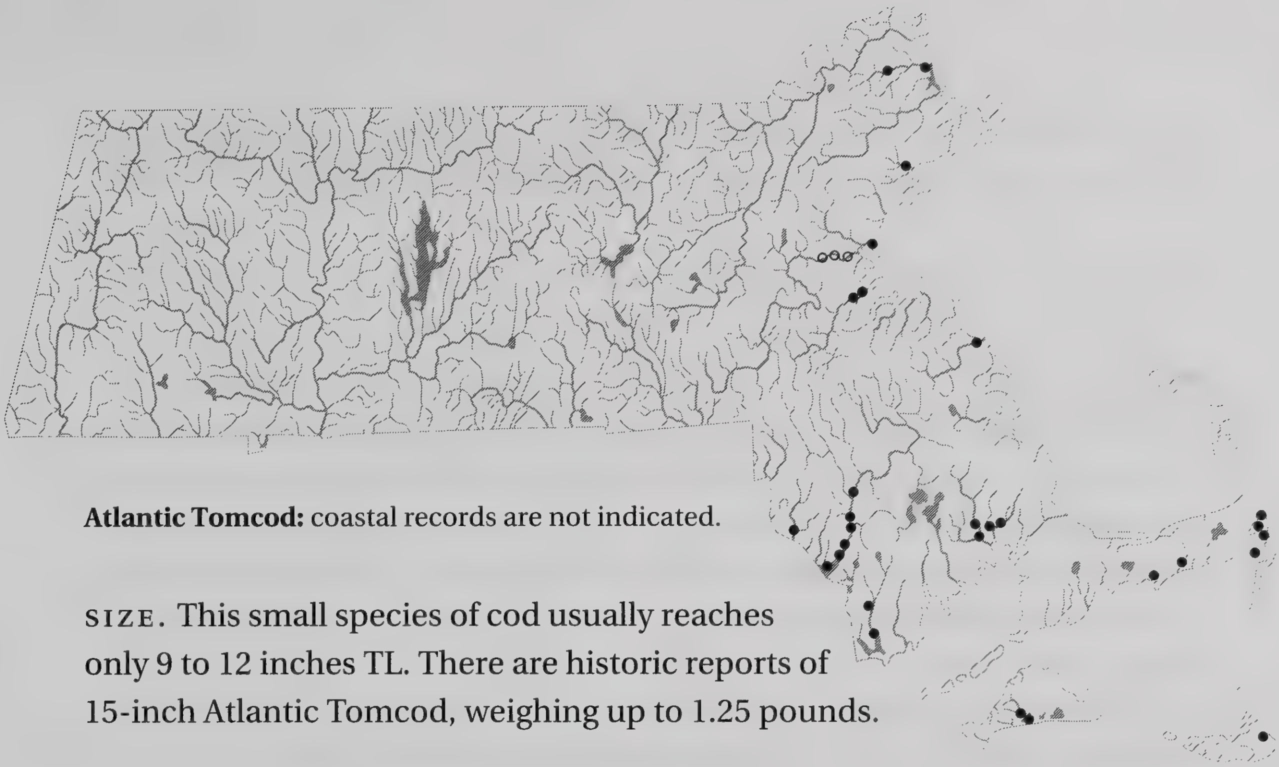
Microgadus tomcod (Walbaum 1792)

PLATE 38



IDENTIFICATION. Atlantic Tomcod have a chin barbel, three dorsal fins, and two anal fins. Its small size, rounded caudal fin, and the filamentous extensions of the second pelvic fin ray distinguish it from the marine Atlantic Cod, *Gadus morhua,* haddock, *Melanogrammus aeglefinus,* and Pollack, *Pollachius virens.*

SELECTED COUNTS. D 11–15,15–19,16–21; A 12–21,16–20; GR 16–21.



Atlantic Tomcod: coastal records are not indicated.

SIZE. This small species of cod usually reaches only 9 to 12 inches TL. There are historic reports of 15-inch Atlantic Tomcod, weighing up to 1.25 pounds.

NATURAL HISTORY. Atlantic Tomcod are most abundant in brackish estuaries and shallow harbors. They move inshore and upstream from October to May, and then downstream to slightly deeper, coastal marine waters in the late spring. Spawning occurs in shallow water during the coldest months of the year, when water temperatures range from 34° to 41°F. Ice often provides cover and may contribute to the suitably low salinities required during the spawning and incubation period. In the Weweantic River estuary in southeast Massachusetts, Atlantic Tomcod spawn between November and late January, with peak activity in late December. Juveniles reach 3 to 3.5 inches TL by July. Growth rate slows during late summer, but as temperatures decline, Atlantic Tomcod resume growth and reach 5 to 7 inches TL at the end of their first year. Most Atlantic Tomcod mature in their second year when they are approximately 10 inches TL. Those inhabiting southern New England estuaries and the Hudson River usually spawn only once and seldom live more than two years. Atlantic Tomcod are opportunistic feeders and prey on a variety of copepods, amphipods, and decapods, as well as small fishes.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Atlantic Tomcod can be expected to occur in most coastal areas. They move to the head of the tide and above in unobstructed coastal streams during the winter spawning season. Storer (1839) noted that 2,000 bushels were taken annually from the Charles River at Watertown. Although still common, Atlantic Tomcod

have declined in some areas. The declines are probably due to changes in the water quality of coastal streams, inner harbors, and bays.

NOTES. Atlantic Tomcod, sometimes called "frostfishes," are delicious and easy to catch. They are often caught by anglers fishing for smelt and will take almost any kind of bait. Atlantic Tomcod remains have been found at Native American archaeological sites as far inland as Marlborough. The species also supported a small, local commercial fishery until about 35 years ago. Although Tomcod can tolerate drastic changes in salinity and temperature, they seem particularly susceptible to acidification, altered stream flow, chemical pollution, and low oxygen levels. Scott and Crossman (1973) state that while "...some other fish species may be able to move out of the region [of pollution], to return when pollution ceases, the tomcod is unable to reproduce and soon disappears entirely from the affected region."

REFERENCES. Bigelow and Schroeder 1953 (general); Clayton et al. 1978 (review); Howe 1971 (life history, Weweantic estuary, MA); McLaren et al. 1988 (life history, Hudson River); Scott and Crossman 1973 (review).

Needlefish Family

Belonidae

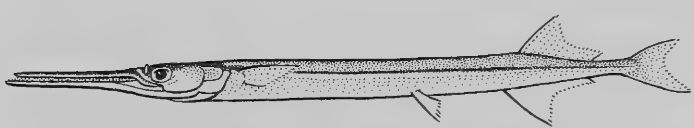
The needlefishes, family Belonidae, are typically found in temperate and tropical marine waters worldwide. However, one-third of the belonid species, such as those from the Amazon River, live their complete lives in freshwater. The needlefishes belong to a relatively small group of fishes, called the Beloniformes, which contain such groups as the flying fishes (Exocoetidae), the halfbeaks (Hemiramphidae), and the sauries (Scomberesocidae). The needlefish family contains 32 species in 10 genera. Three species are found in Massachusetts marine waters, but only one, the Atlantic Needlefish, enters coastal freshwaters. Belonids are elongate fishes with opposing dorsal and anal fins set far back on the body. Most adult needlefishes have elongate upper and lower jaws studded with small, sharp teeth. The development of the jaws is interesting in a evolutionary sense because most needlefishes pass through a stage in which the upper jaw is much shorter than the lower jaw. This elongate lower jaw can be found in some juvenile flyingfishes and persists in the adults of the halfbeaks.

REFERENCES. Collette et al. 1984 (development, relationships); Collette and Berry 1965 (nomenclature, systematics); Collette and Parin 1970 (review, Eastern Atlantic); Cressey and Collette 1970 (copepod parasites).

Atlantic Needlefish

Native

Strongylura marina (Walbaum 1792)



IDENTIFICATION. Needlefishes have elongate bodies, posterior and opposing dorsal and anal fins, and long forcep-like jaws studded with many teeth. The Atlantic Needlefish is the only local species that readily enters freshwaters, but two other species, the Flat Needlefish, *Ablennes hians,* and

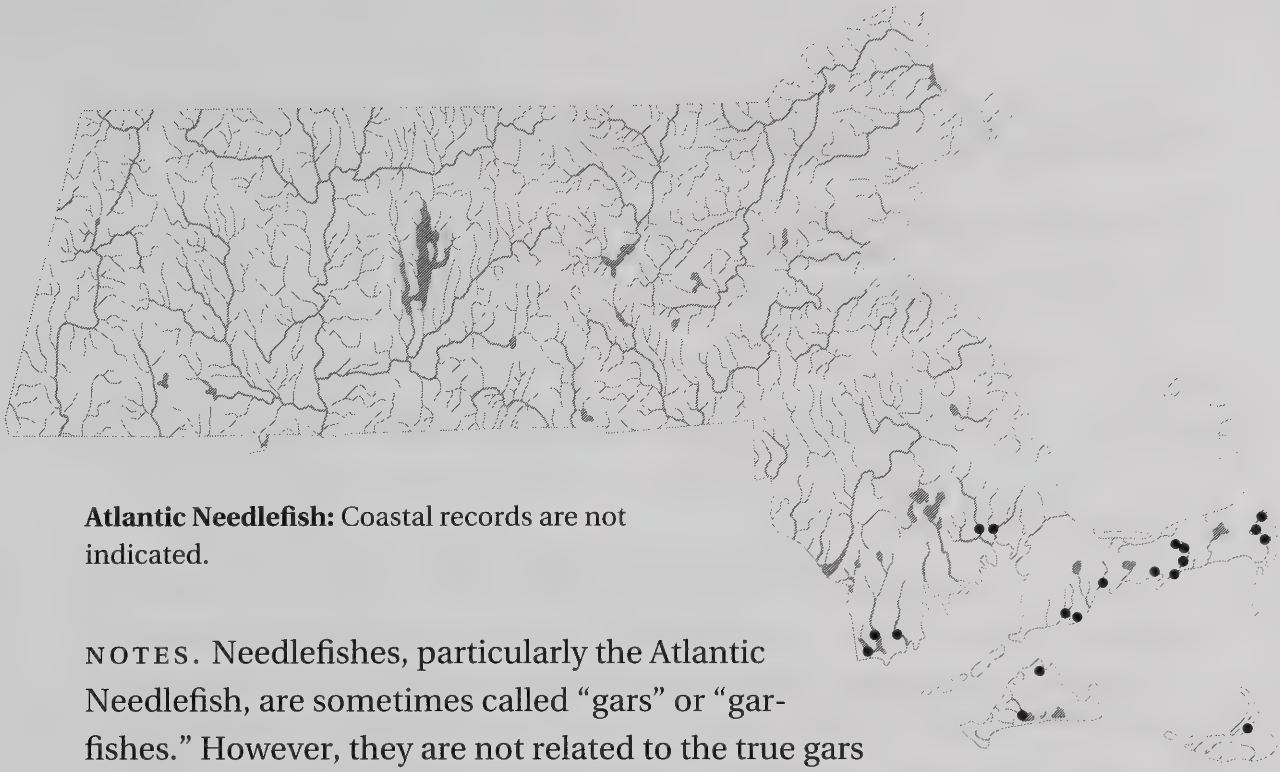
the Agujon, *Tylosurus acus,* occur in marine waters. Atlantic Needlefish have rounded or slightly indented tail fins while the tails of the other two species are deeply forked. In addition, Atlantic Needlefish lack a gonad on their right side.

SELECTED COUNTS. D 14–17; A 16–17; Predorsal scales 213–304.

SIZE. Adults commonly range to 20 inches TL; however, specimens as large as 2 feet TL have been noted (640 mm SL).

NATURAL HISTORY. Atlantic Needlefish are absent from New England waters until early spring, when migrants arrive from the south. The year-round surveys of the Massachusetts Division of Marine Fisheries found them in estuaries between July and October. Adults enter coastal rivers and streams to spawn over submerged vegetation in shallow brackish to fresh waters. After the eggs are deposited, they attach to the vegetation with numerous filaments. Young hatch at 0.75 inches TL with neither of the jaws elongated. As the fish grows, the lower jaw grows faster than the upper, and at 1.5 inches TL, the upper jaw is only one-half the length of the lower. The upper jaw remains shorter than the lower until the young reach approximately 9 inches TL. Young Atlantic Needlefish feed on small crustaceans, particularly shrimp, and switch to small fish such as silversides and killifishes when they are larger than 3 inches TL.

DISTRIBUTION AND ABUNDANCE. Atlantic Needlefish have been found 100 miles up the Hudson River and in the Connecticut River almost to the Massachusetts state line. In Massachusetts, Atlantic Needlefish are common in the coastal rivers and bays south of Cape Cod. They have been recorded from Pleasant and Waquoit bays and in the Bass, Slocums, Wareham, and Westport rivers. Local residents have told us of large “garfishes” in Weir Mill Creek above Follins Pond at the head of the Bass River on Cape Cod during spring. Large numbers have been taken in Pleasant Bay on Cape Cod, but this area lacks major freshwater tributaries. Based on a single larva (0.6 inches TL) collected near the Pilgrim Nuclear Power Plant in Plymouth on July 28, 1977, the species has apparently bred north of Cape Cod in Massachusetts Bay.



Atlantic Needlefish: Coastal records are not indicated.

NOTES. Needlefishes, particularly the Atlantic Needlefish, are sometimes called "gars" or "garfishes." However, they are not related to the true gars (Lepisosteidae) although they superficially resemble the body form of the Longnose Gar, *Lepisosteus osseus.* In the southern parts of their range, Atlantic Needlefish are often used for bait for large sport fishes such as marlins. Needlefishes are eaten in many parts of the world, but not usually in the United States, perhaps because of the green color of their bones.

REFERENCES. Andrews 1973 (juveniles, Nantucket Harbor); Collette 1968, Collette et al. 1984 (relationships, development); Curley et al. 1975 (Bass River); Fiske et al. 1967 (Pleasant Bay); Fiske et al. 1968 (Westport River); Hardy 1978 (review, development); Hoff and Ibara 1977 (Slocums River).

Killifish, Pupfish, and Livebearer Families

Fundulidae, Cyprinodontidae, and Poeciliidae

Killifishes and pupfishes are closely related families within the order Cyprinodontiformes. This diverse order contains up to 800 species that are widely distributed in North America, South America, Europe, Asia, and Africa. Until very recently, killifishes (Fundulidae) and pupfishes (Cyprinodontidae) were placed in a single family; however, these two groups are now recognized as distinct families. The 48 species of killifishes are endemic to North America. Sometimes called minnows, topminnows, bull-minnows, or toothed-minnows, these fishes can be distinguished from the true minnows (Cyprinidae) by their toothed jaws. The name killifish most likely comes from the Dutch word "kills," meaning small waterways, a favorite habitat. Five species of killifishes live in Massachusetts, but one, the Striped Killifish, *Fundulus majalis,* never enters freshwater and is included only in the key for reference. The Cyprinodontidae is comprised of about nine genera and approximately 100 species. Only one species, the Sheepshead Minnow, is found in Massachusetts. A number of the pupfishes inhabit the deserts of the American Southwest and are often restricted to extremely small spring systems. Some pupfishes are able to survive in water that can reach at least 110°F. Due primarily to human manipulation of the region's water supplies, many pupfish species are threatened, and some are already extinct. Killifishes and pupfishes can tolerate low dissolved oxygen and a wide range of salinities and temperatures and are able to survive in habitats too variable and severe for other types of fishes. The estuarine species, in particular, can often survive in small pools that are exposed to high temperatures and become hypersaline. Killifishes have been extensively studied and used as laboratory animals in part because of their ability to survive extreme environmental conditions.

A member of the livebearer family, Poeciliidae, the Mosquitofish, *Gambusia affinis,* was found for the first time in Massachusetts by Steve Hurley (MDFW) in late September 1999. Numerous individuals were found in the Quashnet area of Cape Cod. This group of fishes has internal fertilization and live young and is related to the guppies of the aquarium trade. The

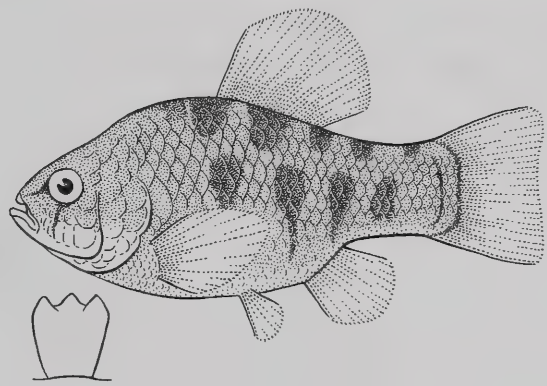
Cape Cod population appears to have reproduced in the wild in 1999, but we cannot predict if the population will survive New England winters.

REFERENCES. Able 1984 (spawning and development); Atz 1986 (laboratory studies); Deacon et al. 1979 (rare and threatened); Griffith 1974 (*Fundulus* environmental tolerances); Parenti 1981 (phylogenetic relationships); Relyea 1983 (*Fundulus*); Rosen 1973 (review); Wiley 1986 (*Fundulus* relationships).

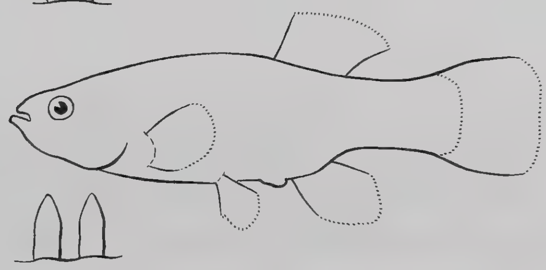
Key to Massachusetts Killifishes and Pupfishes

Note: Mosquitofishes are not included in the key, but they can be easily told from the related killifishes by a dark, tear-drop-like mark below the eye and by the dorsal fin that is almost entirely (females and young) or entirely (males) behind the anal fin base. The males have slender, modified anal fins that serve as their reproductive organ.

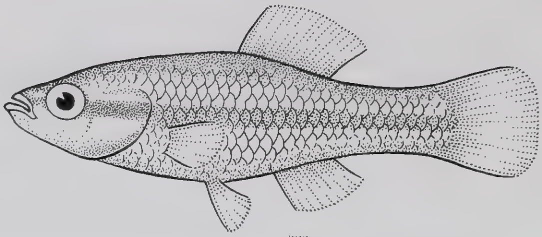
1a. Body deep and robust; pectoral fins reach a point below dorsal origin; jaw teeth wide, with 2 to 3 points. Sheepshead Minnow, *Cyprinodon variegatus*, page 201, Plate 45.



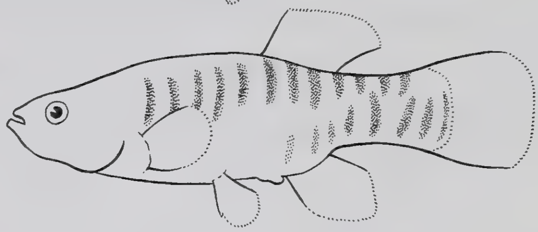
1b. Body elongate; pectoral fins end well before a point below the dorsal fin origin; teeth conical. Go to 2.



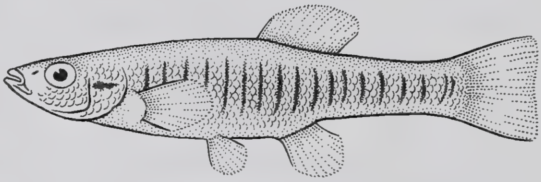
2a. Jaw teeth strongly conical, usually in a single row; fewer than 30 lateral line scales; scales outlined with fine markings; occasional with diffuse bands on body. Rainwater Killifish, *Lucania parva,* page 209, Plate 44.



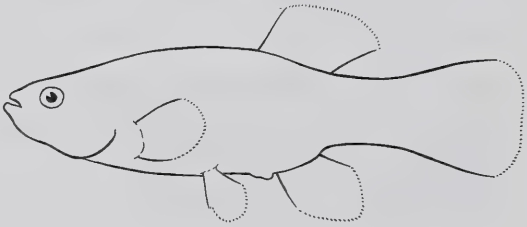
2b. Jaw teeth pointed and set in bands, often buried in tissue; more than 30 lateral line scales, not outlined as above; usually with bands or stripes on body. Go to 3.



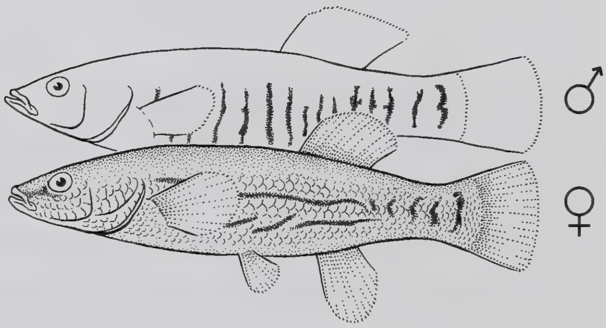
3a. Lateral scales usually 40 or more; distance from dorsal origin to end of caudal peduncle about equal to distance from dorsal origin to eye. Banded Killifish, *Fundulus diaphanus,* page 203, Plate 46.



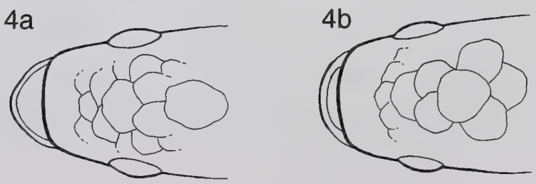
3b. Lateral scales less than 35; distance from dorsal origin to end of caudal peduncle much less than the distance from dorsal origin to eye. Go to 4.



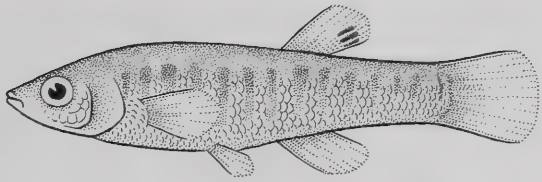
4a. Snout and upper jaw relatively long and pointed (when viewed from side and above); prominent black, irregular stripes or bars on body. Striped Killifish, *Fundulus majalis.* See family account.



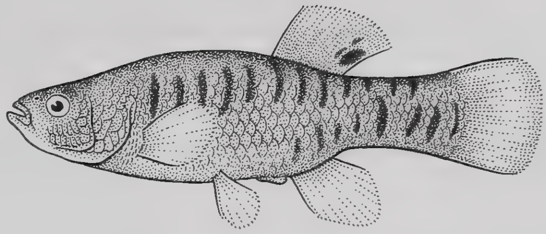
4b. Snout and upper jaw relatively short and rounded; stripes never present; vertical bars not prominent or absent. Go to 5.



5a. Narrow middorsal band from nape to dorsal origin; base of dorsal fin shorter than base of anal fin; 8 dorsal fin rays. Spotfin Killifish, *Fundulus luciae*, page 207, Plate 47.



5b. Middorsal band absent (only a small spot at dorsal origin); base of dorsal fin equal to or greater than length of the base of the anal fin; dorsal fin rays more than 11. Mummichog, *Fundulus heteroclitus*, page 205, Plate 48.

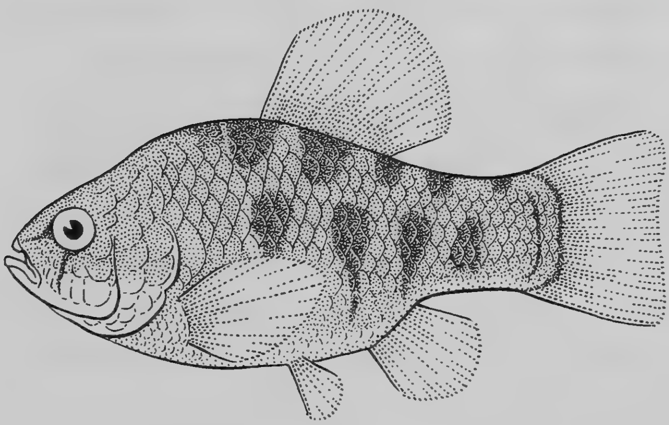


Sheepshead Minnow

Native

Cyprinodon variegatus Lacepède 1803

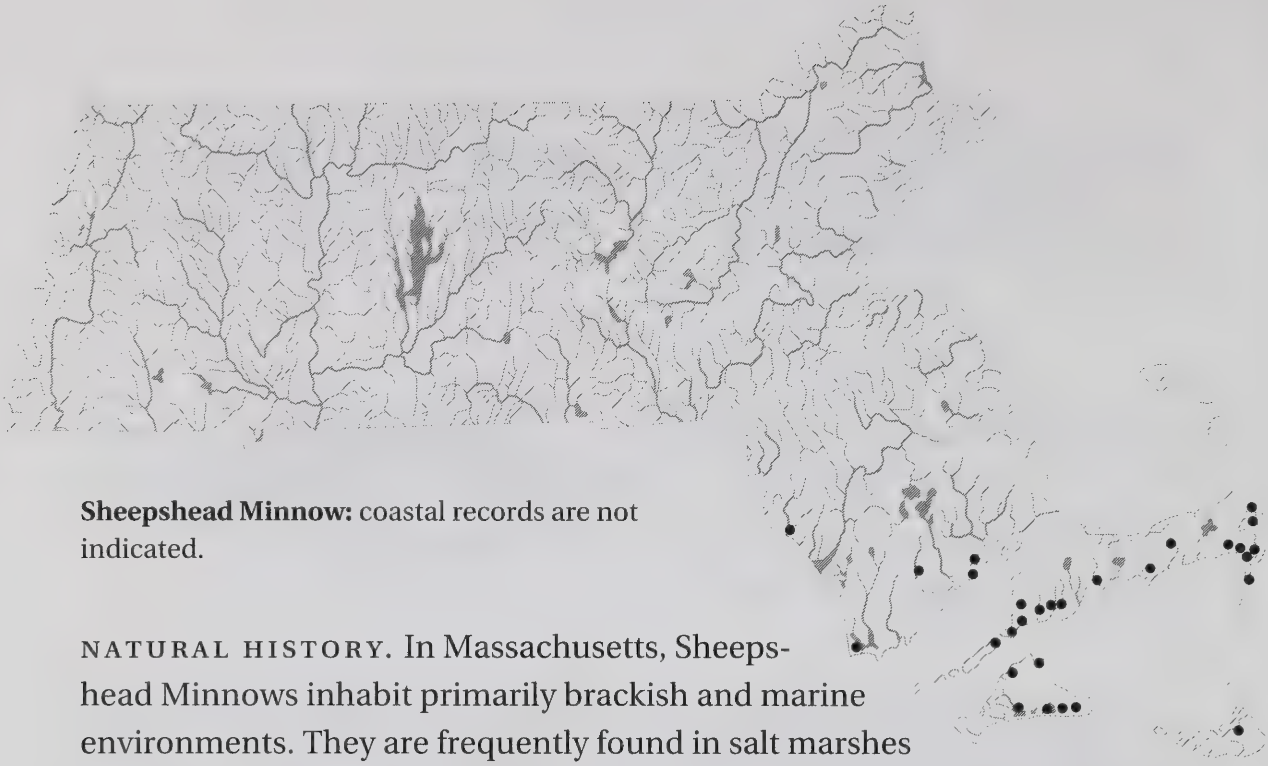
PLATE 45



IDENTIFICATION. Sheepshead Minnows have a stout, deep body and flattened jaw teeth with two to three cusps (see key Figure 1a). The end of the pectoral fin always reaches a point well behind the origin of the dorsal fin. Adult females have a conspicuous dark spot on the dorsal fin while adult males have a distinctive dark edge on the caudal fin. Breeding males become light to steel-blue dorsally and yellow to salmon color ventrally.

SELECTED COUNTS. D 11–12; A 10–11; Scales 24–27.

SIZE. Sheepshead Minnows are small fish, rarely reaching 3 inches TL. Males are larger than females.



Sheepshead Minnow: coastal records are not indicated.

NATURAL HISTORY. In Massachusetts, Sheepshead Minnows inhabit primarily brackish and marine environments. They are frequently found in salt marshes and tidal creeks and occasionally enter tidal freshwater. Sheepshead Minnows are omnivorous, eating a wide variety of animal and plant material, including small invertebrates, zooplankton, small fishes, and various marine algae. They are pugnacious fishes, fighting vigorously with members of their own species and with other fishes during an extended midspring to late-summer spawning season. Spawning occurs in shallow water, usually in association with aquatic vegetation. During spawning, the male holds the female while the eggs are released. Eggs mature a few at a time, and they are released as they ripen. Laid singly or in small groups throughout the spawning season, the eggs sink and stick to aquatic vegetation or other substrates. The eggs hatch in less than a week, and juveniles mature in under a year.

DISTRIBUTION AND ABUNDANCE. Cape Cod is the northernmost part of the Sheepshead's range. In these northern areas they live primarily in brackish and marine environments, but in Florida and along the Gulf coasts of the United States and Mexico, Sheepshead Minnows often live in completely freshwater habitats. In Massachusetts, Sheepshead Minnows seldom move beyond the influence of the tide. They are common on the south shore of Cape Cod, in areas along the Elizabeth Islands, and on Martha's Vineyard and Nantucket. They are occasionally found in tidal freshwater or in low salinity coastal overwash ponds. There are no records from the Gulf of Maine north of Cape Cod.

NOTES. Sheepshead Minnows have been divided into four subspecies with *C. v. ovinus* found in New England. As in the Rainwater Killifish, the New England population of Sheepshead Minnow exhibits some noticeable morphological variations when compared with the southern populations.

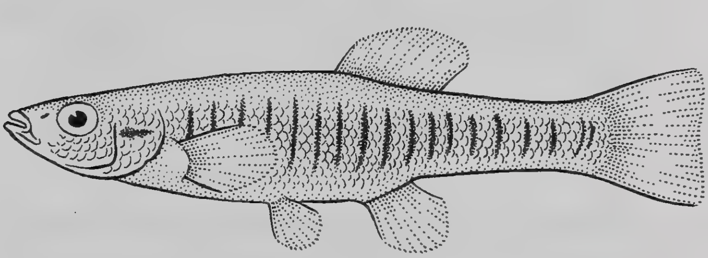
REFERENCES. Bigelow and Schroeder 1953 (general); Breder and Rosen 1966 (reproduction); Hardy 1978 (development, review); White et al. 1986 (life history); Stallsmith 1997 (Nantucket).

Banded Killifish

Native

Fundulus diaphanus Lesueur 1817

PLATE 46

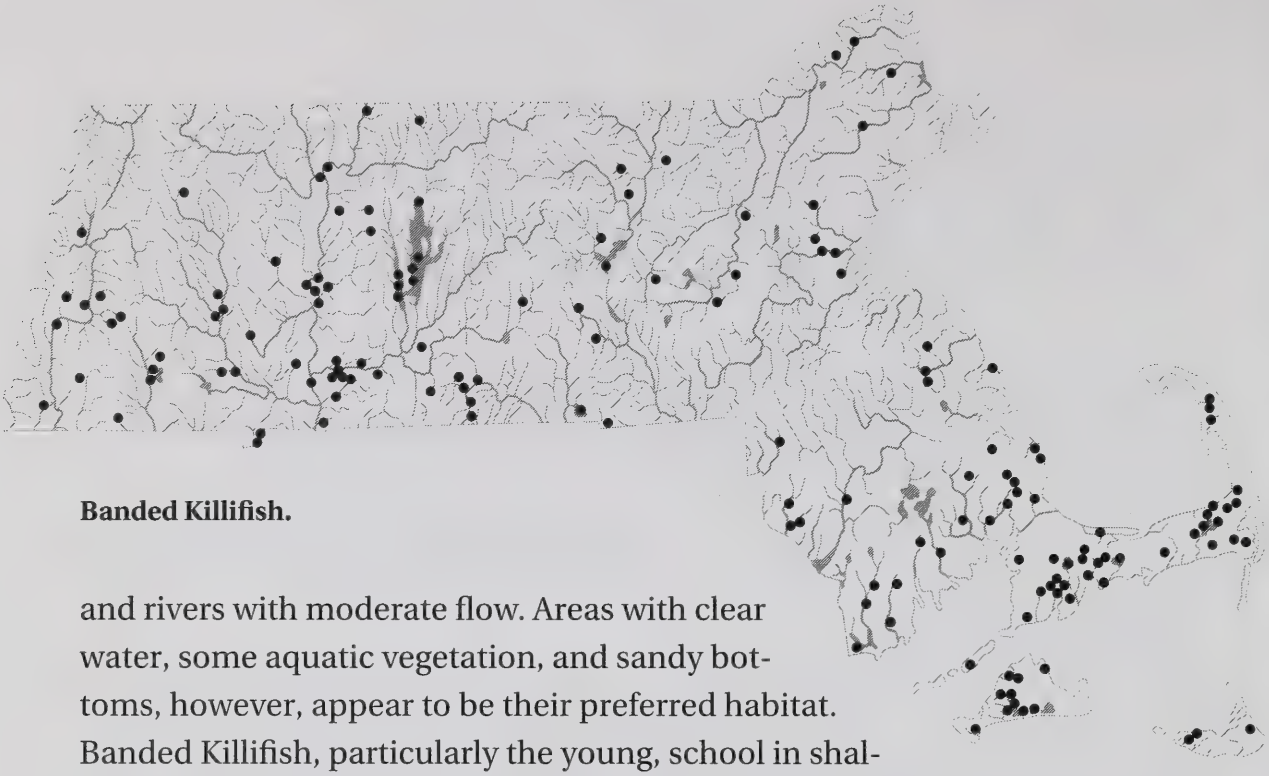


IDENTIFICATION. Banded Killifish are more elongate and have a narrower caudal peduncle than other Massachusetts killifishes; the distance from the dorsal origin to the base of the caudal peduncle usually reaches mideye or beyond. Banded Killifish usually have more than 41 lateral scales and have 18 to 22 dark bands along the sides of the body. In males, the pelvic and anal fins are sometimes edged with white, and their body color becomes more intense with shades of blue during the spawning season.

SELECTED COUNTS. D 12–15; A 10–13; Scales 39–49.

SIZE. Banded Killifish of about 3 inches TL are most commonly encountered, but specimens of almost 6 inches TL (117 mm SL) have been collected from Massachusetts.

NATURAL HISTORY. Banded Killifish typically inhabit freshwater but occasionally enter slightly brackish water. An adaptable species, they may be found in a wide variety of habitats, including ponds and lakes or streams



Banded Killifish.

and rivers with moderate flow. Areas with clear water, some aquatic vegetation, and sandy bottoms, however, appear to be their preferred habitat. Banded Killifish, particularly the young, school in shallow water along the shore. Spawning occurs from midspring to midsummer, as males establish small territories along the edges of aquatic vegetation. Males and females temporarily form pairs, and eggs are laid singly or in small groups in the vegetation. Males are active during spawning and vigorously herd the females to their territories and hold the females close to their bodies with their fins. Spawning is probably protracted, and females release only a few eggs at a time; the eggs hatch in one to two weeks. Banded Killifish are primarily carnivorous. Many different aquatic invertebrates are taken at various depths, and not just from the surface, as the morphology of their upturned mouths might suggest. Fish eggs and larvae are also eaten. Banded Killifish are preyed upon by many warm- and cold-water game fishes, birds, and mammals. As a defensive behavior, Banded Killifish will burrow into the substrate when threatened by a potential predator.

DISTRIBUTION AND ABUNDANCE. Banded Killifish are common where found in Massachusetts. There are records of this species from most of the major river drainages; however, populations seem to be somewhat localized within any given drainage.

NOTES. The eastern subspecies of the Banded Killifish, *F. d. diaphanus,* is found from South Carolina north to Newfoundland. It is most closely related to the Waccamaw Killifish, *F. waccamensis,* which is endemic to two lakes in North Carolina.

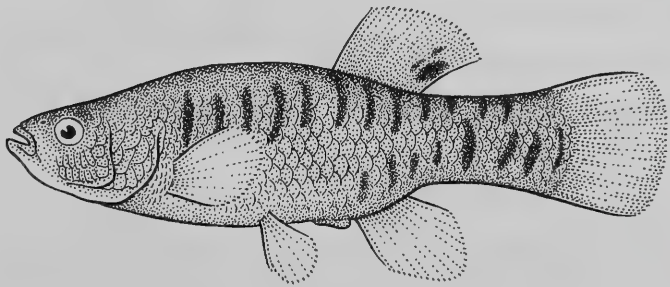
REFERENCES. Baker-Dittus 1978 (ecology); Colgan 1974 (defensive behavior); Godin 1986 (schooling); Hardy 1978 (development); Kenney 1981 (early age and growth, MA); Keast and Webb 1966 (general biology); Scott and Crossman 1973 (general biology); Weisberg 1986 (ecology); Wiley 1986 (relationships).

Mummichog

Native

Fundulus heteroclitus (Linnaeus 1766)

PLATE 48

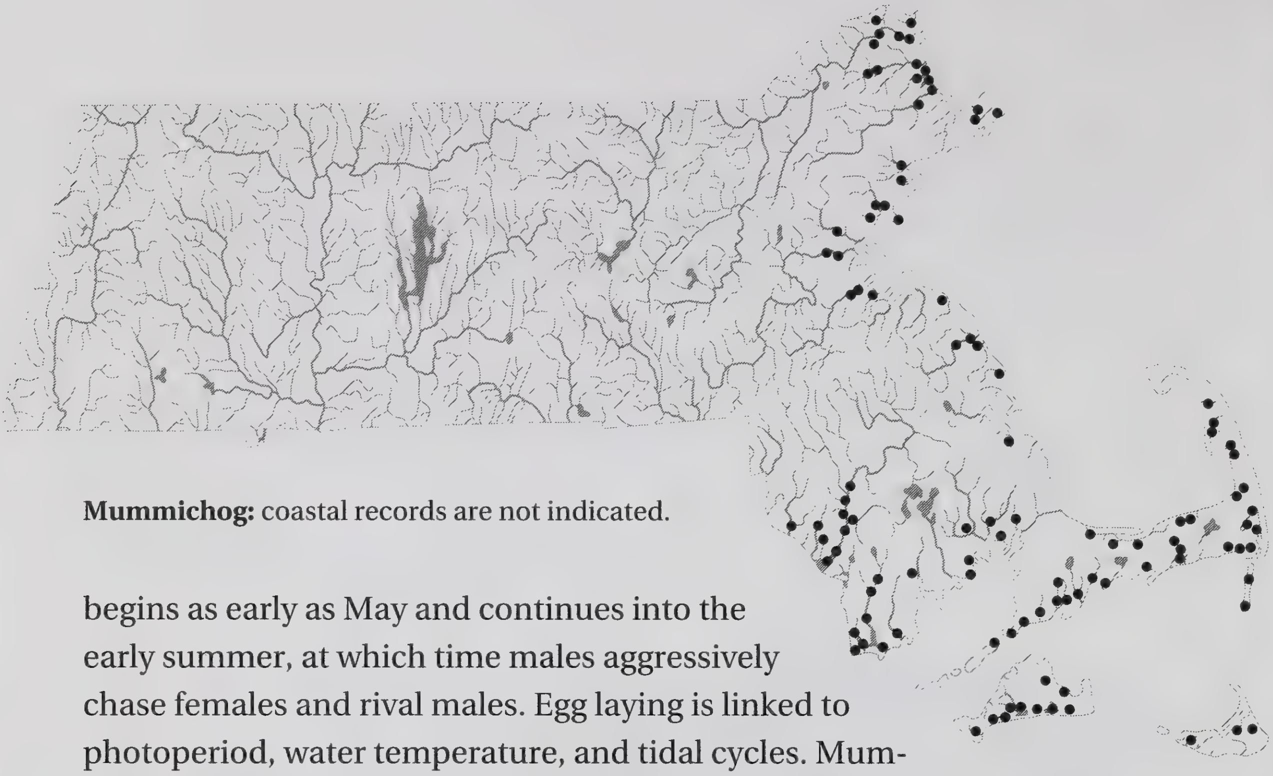


IDENTIFICATION. Mummichogs are stout-bodied, with 11 to 12 dorsal fin rays and fewer than 36 lateral scales. They lack the jet black banding and longitudinal striping found on Striped Killifish. Banded Killifish are more elongate and have more bands than Mummichogs. Juvenile Mummichogs might be confused with adults of the locally uncommon Spotfin Killifish (see Spotfin Killifish account). Mummichogs are light yellow to olive with faint bands or irregular markings on the body. The belly is light in color, varying in hue from white to yellow. A dark spot is often found on the posterior margin of the dorsal fin in males.

SELECTED COUNTS. D 11–12; A 11–12; Scales 34–36; GR 9–11.

SIZE. Mummichogs are commonly 3 to 4 inches TL, but the maximum size is about 6 inches TL. The largest Massachusetts specimen that we have measured is about 5 inches TL (111 mm SL).

NATURAL HISTORY. Mummichogs are among the hardiest of fishes and can survive in water temperatures of at least 90°F, and salinities of freshwater to well over that of seawater. Mummichogs are most commonly found in bays, estuaries, saltmarsh pools, and tidal freshwater. Spawning



Mummichog: coastal records are not indicated.

begins as early as May and continues into the early summer, at which time males aggressively chase females and rival males. Egg laying is linked to photoperiod, water temperature, and tidal cycles. Mummichogs use the intertidal marsh for spawning during spring tides. Eggs are deposited singly or in small groups near the high water mark. The eggs remain out of water for much of their development. In New England, females deposit their eggs in sand or algal mats. In other areas, eggs are often laid in empty mussel shells or at the base of *Spartina* leaves. Hatching is triggered by the next high tide, when water again completely covers the fully developed eggs. Although the eggs are out of water for much of their development, surprisingly little egg mortality occurs. The omnivorous Mummichog's diet consists of small invertebrates, including amphipods, crustaceans, and mollusks. This species also consumes small fishes, including smaller Mummichogs and Mummichog eggs. Plant material and detritus are frequently ingested but are apparently not nutritionally important.

DISTRIBUTION AND ABUNDANCE. The northern subspecies, *F. h. macrolepidotus,* is found north of Long Island, NY, and is abundant all along the coast of Massachusetts. This species is most often encountered in coastal marsh creeks, ditches, and tide pools. Mummichogs frequently enter tidal freshwater and coastal ponds that vary in salinity.

NOTES. Mummichogs are often used as laboratory animals, particularly in studies of fish development, the endocrine system, or pollution. They are sometimes called "salt water minnows" or just "minnows" and are frequently used as bait. This abundant species plays an important role in

coastal marsh ecology as it affects invertebrate populations and provides food for many species of birds and fishes.

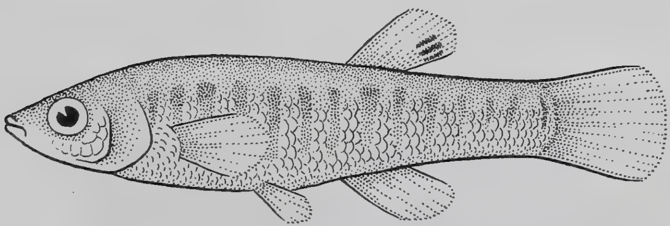
REFERENCES. Able and Felley 1986 (morphological variations); Atz 1986 (laboratory use); Collette and Hartel 1988 (Pamet River); Eisler 1986 (pollution); Kneib 1984, 1986 (ecology); Relyea 1983; Taylor 1986; Able and Hata 1984 (reproduction); Weisberg 1986 (competition); White et al. 1986 (life history).

Spotfin Killifish

Native

Fundulus luciae (Baird 1855)

PLATE 47

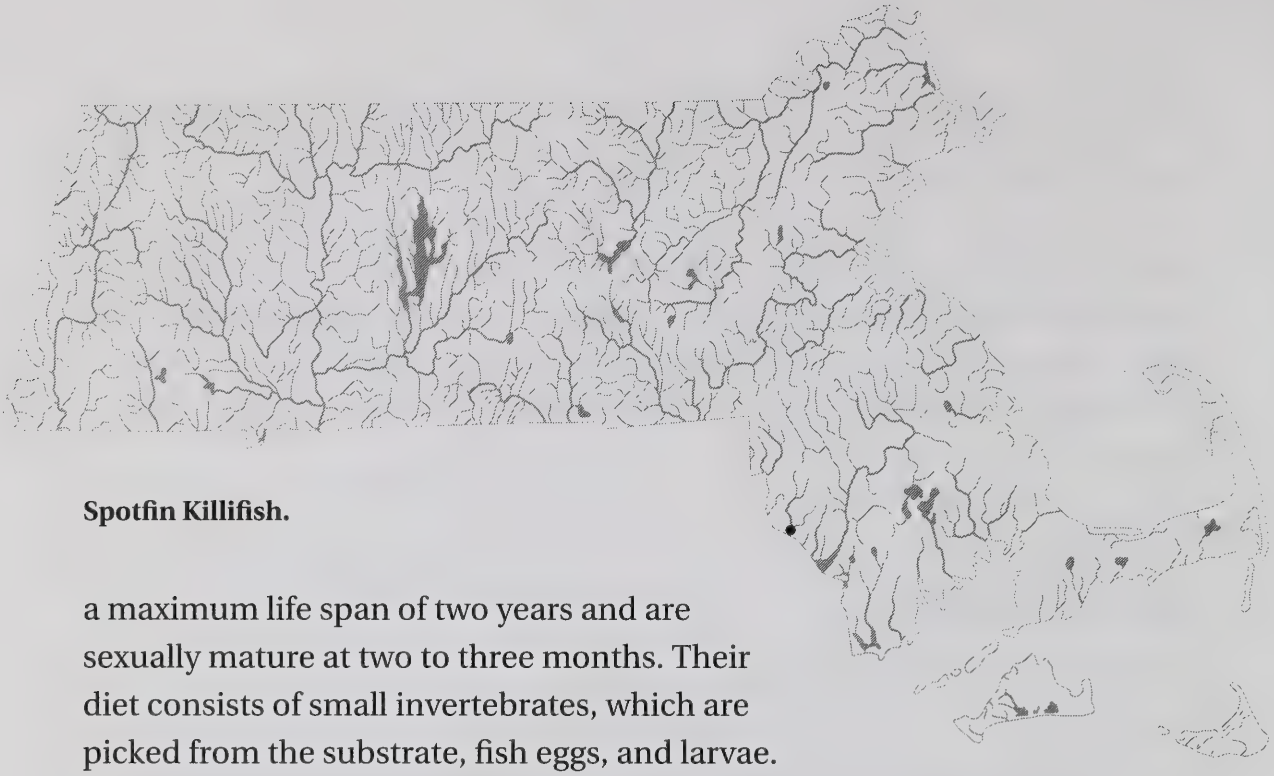


IDENTIFICATION. Spotfin Killifish can be told from the other *Fundulus* by a more posterior dorsal fin that has only eight rays. Spotfin Killifish are most similar to young Mummichogs but have a dorsal midline stripe from the nape to the dorsal fin origin (see key Figure 5a).

SELECTED COUNTS. D 8; A 10; Scales 34–36.

SIZE. Spotfin Killifish are the smallest member of the genus *Fundulus.* Adults rarely reach 2 inches TL.

NATURAL HISTORY. Spotfin Killifish inhabit quiet bays and estuaries. They are typically found in the upper regions of salt marshes and on rare occasions in tidal freshwater. Their preferred habitat seems to be high intertidal marshes that do not flood on every tide. In these locations, Spotfin Killifish are found in shallow, often temporary pools and have been observed swimming in areas of marsh vegetation covered by as little as one-quarter inch of water. Spawning, which occurs in late spring and summer, is most likely associated with the cycle of high tides. Spotfin Killifish have



Spotfin Killifish.

a maximum life span of two years and are sexually mature at two to three months. Their diet consists of small invertebrates, which are picked from the substrate, fish eggs, and larvae.

DISTRIBUTION AND ABUNDANCE. Southern Massachusetts is the northernmost part of the range of the Spotfin Killifish. The first Massachusetts record is based on our collection of seven reproductively active males and females (24 to 29 mm SL) that we found in the Palmer River, Rehoboth, on June 7, 1980. These specimens were collected in a shallow mosquito ditch and over a *Spartina* marsh flooded to 1 or 2 inches by a high spring tide. In June 1999, Bruce Stallsmith found this species common in a similar habitat along the Palmer River in Swansea and Rehoboth.

NOTES. In the past, this species was considered rare; however, recent studies show that it is locally common in some parts of its range. The lack of records of Spotfin Killifish is most likely due to the species' preference for high tidal marsh habitats that biologists seldom sample for fishes. It is also probable that this species is often mistaken for the young of other killifishes.

REFERENCES. Able et al. 1983 (status, NJ); Brill 1987 (natural history, propagation); Hardy 1978 (review, development); Kneib 1978 (general biology); Kneib 1984 (larval and juvenile ecology); Weisberg 1986 (ecology).

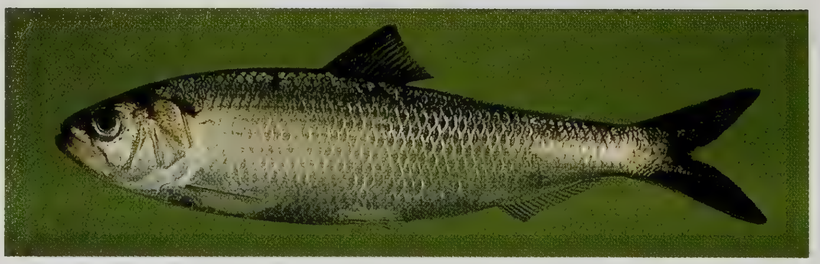
Color Plates

The following photographs were taken in Massachusetts by K.E. Hartel unless indicated otherwise. All measurements are in SL.

1) American Brook Lamprey, adult 135mm, Blackstone Drainage, 1981, MCZ 62174. Photo by B. Byrne (MDFW).

2) Sea Lamprey, transformed juvenile 156mm, Shawsheen River, Lawrence, 1998, MCZ 155273.

3) Shortnose Sturgeon, adult (above), and Atlantic Sturgeon, juvenile (below), Merrimack River, 1990. Photo by Boyd Kynard (USFW).

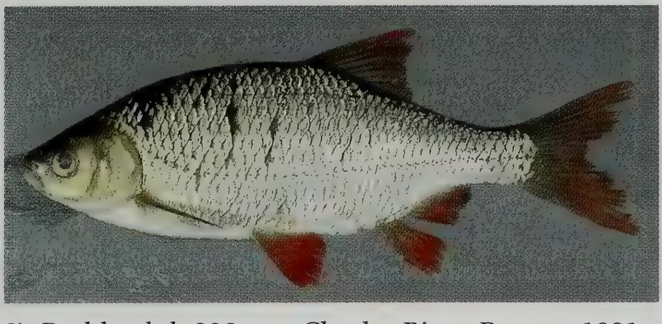


4) Blueback Herring, adult 192mm, Charles River, 1999, MCZ 99410.

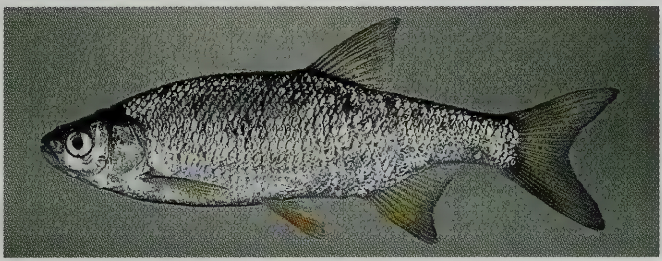
5) Blueback Herring, juvenile 61mm (above), MCZ 58160; Alewife, juvenile 56mm (below), MCZ 58159. Both Herring River, Wellfleet, October 1981.

6) American Shad, adult. Photo by D. Flescher, courtesy American Fisheries Society.

7) Gizzard Shad, adult 235mm, Connecticut River, Northhampton, 1986, MCZ 64569.



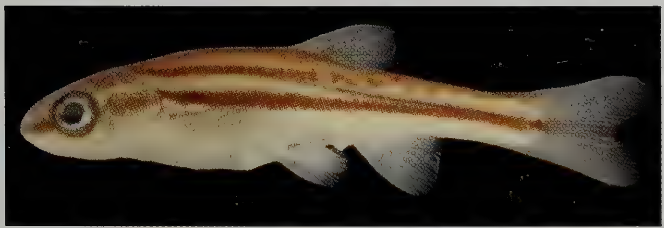
8) Rudd, adult 206mm, Charles River, Boston, 1991, MCZ 95616.



9) Golden Shiner, adult 120mm, Assabet River, Concord Drainage, 1988, MCZ 99392.

10) Goldfish, adult, aquarium specimen.

11) Common Carp, juvenile 54mm, Connecticut River, 1980, MCZ 57115.



12) Northern Redbelly Dace, adult 35mm, Deerfield Drainage, 1979, MCZ 54699.

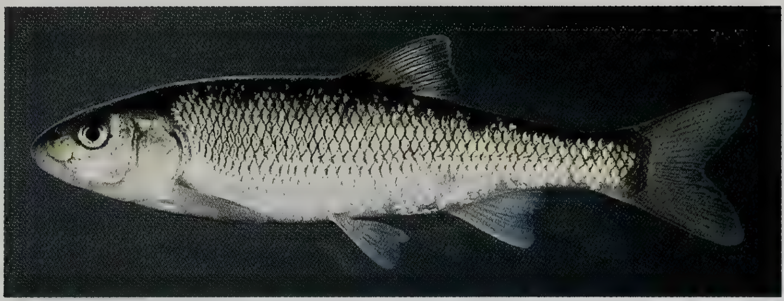
13) Lake Chub, adult 77mm, Middle Branch Westfield River, 1950, MCZ 54694.

14) Eastern Silvery Minnow, adult 71mm, Connecticut River, Hadley, 1950, UMA 35-1.

15) Spottail Shiner, adult 77mm, Charles River, 1988, MCZ 99409.

16) Mimic Shiner, adult 49mm, Connecticut River, 1980, MCZ 57159.

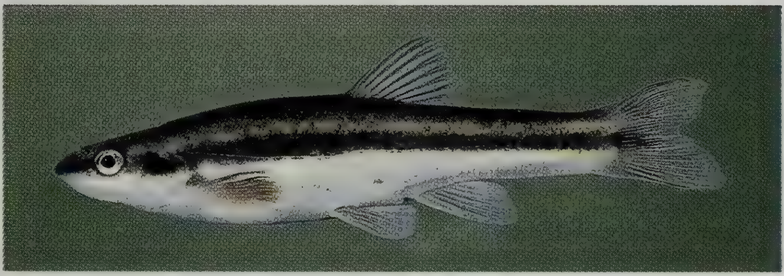
17) Common Shiner, adult 57mm, Deerfield Drainage, 1981, MCZ 56516.



18) Fallfish, adult 146mm, Center Brook, Blackstone Drainage, 1988, MCZ 99404.

19) Creek Chub, adult 69mm, South River, Conway, 1980, MCZ 57263.

20) Bridle Shiner, adult 36mm, Parker Drainage, 1988, MCZ 95249.

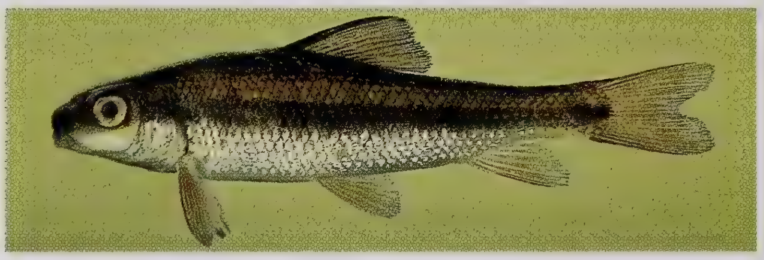


21) Blacknose Dace, adult 61mm, S. Wachusetts Brook, Nashua Drainage, 1988, MCZ 99395.

22) Longnose Dace, adult 94mm, Gates Brook, Nashua Drainage, MCZ 99398.

23) Bluntnose Minnow, adult 64mm, Housatonic River, 1979, MCZ 56433.

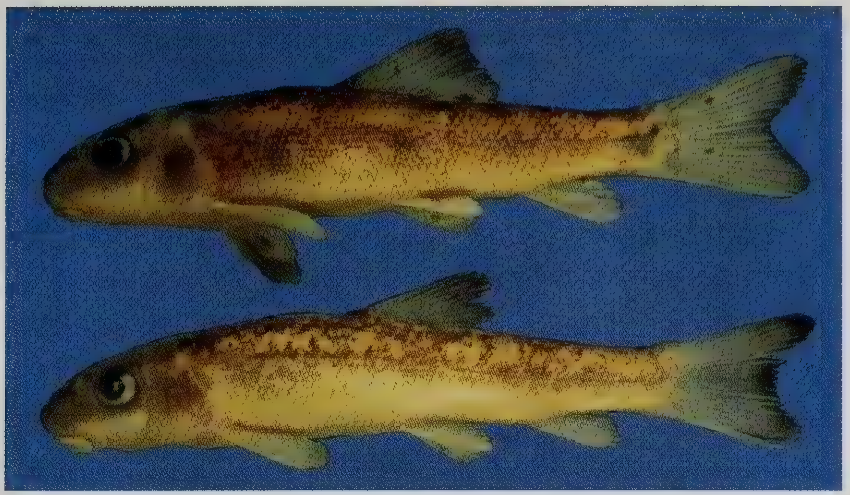
24) Fathead Minnow, adult 42mm, Housatonic River, 1979, MCZ 56431.



25) Creek Chubsucker, subadult 55mm, Merrimack Drainage, 1988, MCZ 99412.

26) White Sucker, adult 180mm, Center Brook, Blackstone Drainage, 1988, MCZ 99397.

27) Longnose Sucker, adult 172mm, North River, Deerfield Drainage, 1981, MCZ 57101.



28) White Sucker, juvenile (above) and Longnose Sucker, juvenile (below). Each about 40mm, both Housatonic Drainage, 1979.

29) Central Mudminnow, adult 36mm, Connecticut Drainage, 1980, MCZ 56943.

30) Trout-perch, adult 72mm, Green River, Housatonic Drainage, 1940, MCZ 54922.

31) White Catfish, adult 255mm, Charles River, 1988, MCZ 79899.

32) Brown Bullhead, adult 160mm, Center Brook, Blackstone Drainage, 1988, MCZ 99399.

33) Yellow Bullhead, adult 95mm, Merrimack Drainage, 1988, MCZ 99413.

34) Channel Catfish, used by permission of R.S. Wydoski and R.R. Whitney, 1979. *Inland Fishes of Washington*, University of Washington Press, Seattle.

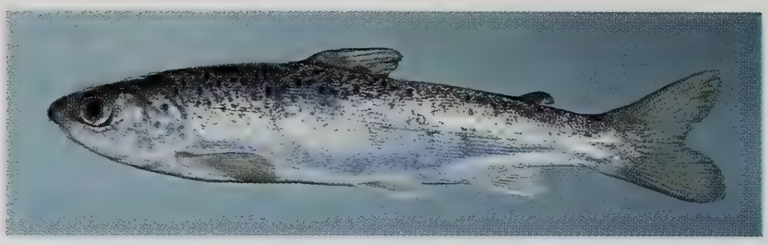
35) Tadpole Madtom, adult 78mm, Howe Pond, Chicopee Drainage, 1978, MCZ 54224.

36) Redfin Pickerel, adult 127mm, Center Brook, Blackstone Drainage, 1988, MCZ 99400.

37) Chain Pickerel, adult 191mm, Center Brook, Blackstone Drainage, 1988, MCZ 99402.

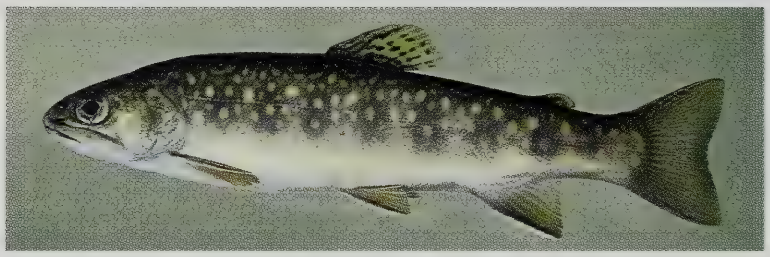
38) Atlantic Tomcod, juvenile 60mm, Taunton River, 1980, MCZ 57295.

39) Burbot, juvenile, Third Connecticut Lake, NH, 1985, MCZ 63017.



40) Atlantic Salmon, juvenile 145mm, Gates Brook, Nashua Drainage, 1988, MCZ 99393.

41) Brown Trout, adult 170mm, Gates Brook, Nashua Drainage, 1988, MCZ 99406.



42) Brook Trout, adult 150mm, S. Wachusetts Brook, Nashua Drainage, 1988, MCZ 99407.

43) Rainbow Smelt, adult 101 mm, Malden Brook, Nashua Drainage, 1984, MCZ 93565.

44) Rainwater Killifish, adult 30mm, Buzzards Bay Drainage, 1980, MCZ 57136.

45) Sheepshead Minnow, adult 36mm, Cape Cod Drainage, 1980, MCZ 57142.

46) Banded Killifish, adult 70mm, Charles River, Boston, 1980, MCZ 59059.

47) Spotfin Killifish, adults, female 27mm (above), male 24mm (below), Palmer River, Rehoboth, 1980, MCZ 57600.

48) Mummichog, adult 60mm, Neponset River, 1988, MCZ 99421.

49) Fourspine Stickleback, adult 32mm, Neponset River, 1980, MCZ 99420.

50) Threespine Stickleback, adult 35mm, Olmstead Park, Boston, 1988, MCZ 99417.

51) Blackspotted Stickleback, adult 37mm, Cohasset, 1977, MCZ 52753.

52) Ninespine Stickleback, adult 47mm, Eel River, Cape Cod Drainage, 1988, MCZ 99418.

53) Inland Silverside, adult 45mm (above), Charles River, 1979, MCZ 56124; Atlantic Silverside, adult 51mm (below), Neponset River, 1979, MCZ 56238.

54) Slimy Sculpin, adult 70mm, S. Wachusetts Brook, Nashua Drainage, 1988, MCZ 99405.

55) Hogchoker, subadult 57mm, Palmer River, Rehoboth, 1981, MCZ 58244.

56) White Perch, adult 130mm, Charles River, 1988, MCZ 99411.

57) Banded Sunfish, adult, Merrimack Drainage, 1988.

58) Black Crappie, juvenile 79mm, Charles River, 1979, MCZ 56551.

59) Bluegill, adult 143mm, Charles River, 1988, MCZ 99422.

60) Rock Bass, 120mm, Merrimack River, New Hampshire state line, 1990, MCZ 95848.

61) Redbreast Sunfish, adult 110mm, Charles River, 1988, MCZ 99426.

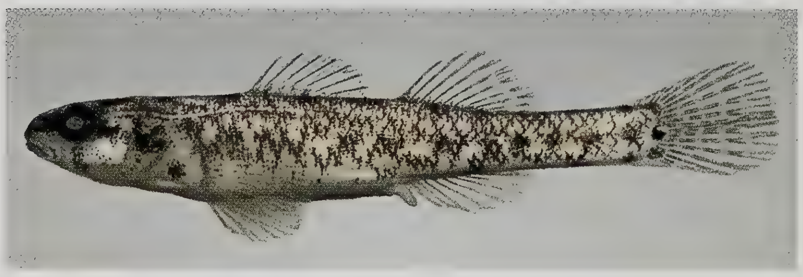
62) Pumpkinseed, adult 95mm, Assabet River, Concord Drainage, 1988, MCZ 99401.

63) Smallmouth Bass, subadult, 169mm, Johns Creek, Virginia, 1984. Photo by R.E. Jenkins.

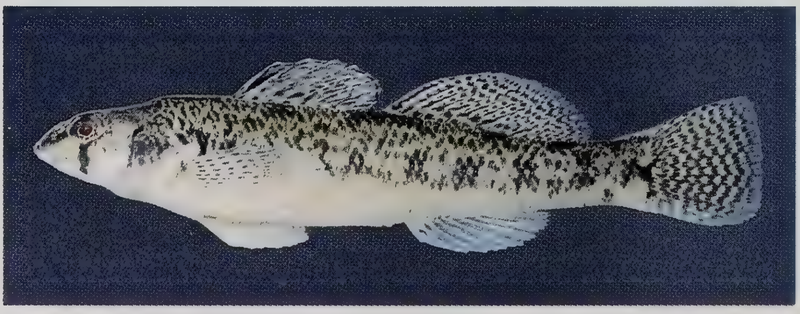
64) Largemouth Bass, adult 115mm, Assabet River, Concord Drainage, 1988, MCZ 99394.

65) Largemouth Bass, juvenile 60mm (above), Merrimack River, 1979, MCZ 57279; Smallmouth Bass, juvenile 56mm (below), Connecticut River, 1980, MCZ 57344.

66) Yellow Perch, adult 115mm, Charles River, 1988, MCZ 99419.



67) Swamp Darter, adult 29mm, Gibbs Pond, Nantucket, MCZ 58231.



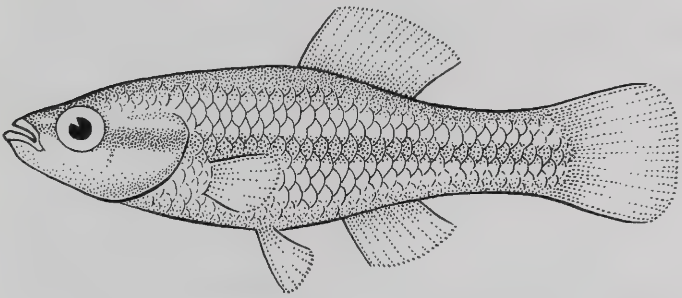
68) Tessellated Darter, adult 60mm, Center Brook, Blackstone Drainage, 1988, MCZ 99403.

Rainwater Killifish

Native

Lucania parva (Baird and Girard 1855)

PLATE 44

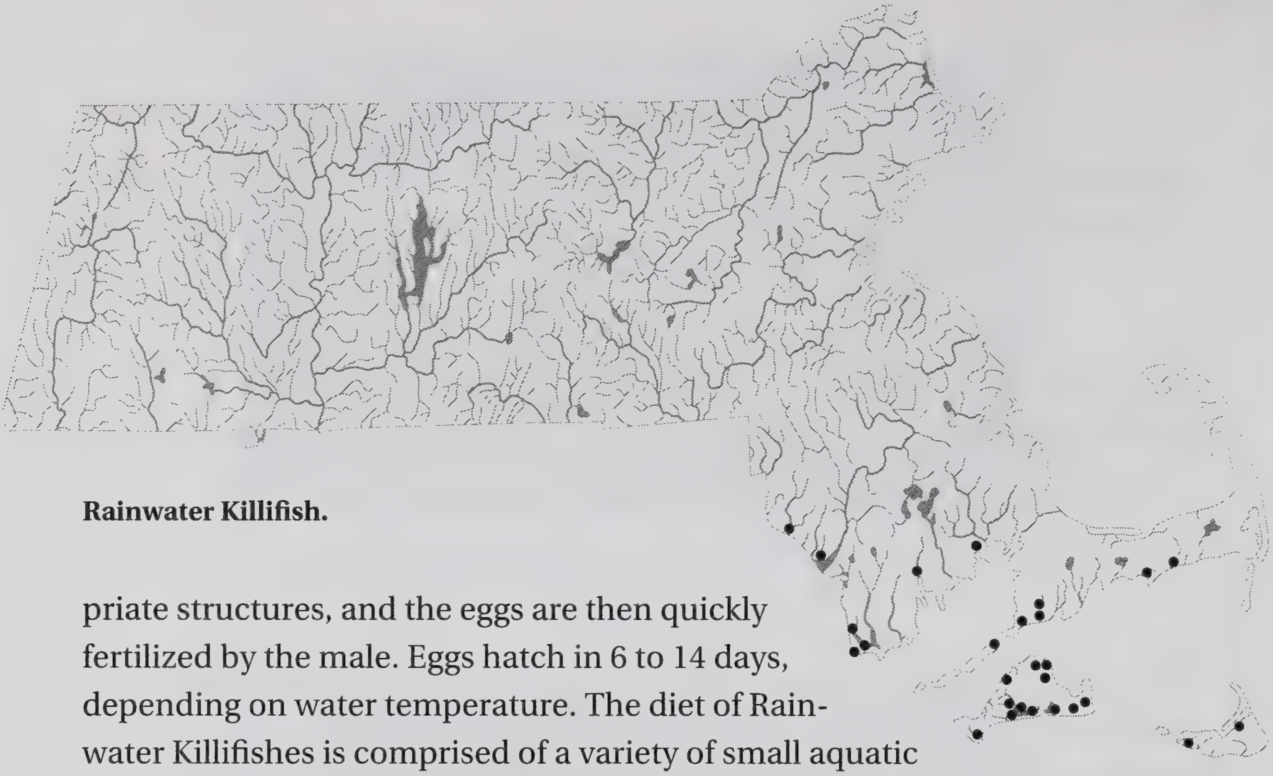


IDENTIFICATION. Rainwater Killifish have caninelike teeth in a single row, relatively short bodies with large scales, and pectoral fins that extend back to a point just before the origin of the dorsal fin. Each scale is delicately outlined to give the body a crosshatched appearance. Most males have a small, dark spot on the lower anterior edge of the dorsal fin; during breeding the fins have an orange-red wash, and the dorsal, caudal, anal, and pelvic fins have dark edging.

SELECTED COUNTS. D 11–12; A 10–11; Scales 25–26.

SIZE. Rainwater Killifish are small, usually reaching only 1.5 inches TL. The largest Massachusetts specimen that we have seen is about 2 inches TL.

NATURAL HISTORY. This small fish is tolerant of a wide range of water conditions, from freshwater to hypersaline pools in salt marshes. A schooling species, generally associated with aquatic vegetation, Rainwater Killifish are most often found in salt marsh creeks and estuaries. In some areas, however, this species naturally inhabits large rivers and streams. In Massachusetts, they are most common in coastal marshes, creeks, and overwash ponds, although they occasionally move into tidal freshwaters. Rainwater Killifish travel in schools and may move from brackish to freshwater during the breeding season. Males become territorial during the late spring and summer spawning season, defending small areas near aquatic vegetation. Females are actively courted and enticed into the males' territories by a series of energetic displays. If receptive, a female follows a male to his territory and deposits several eggs close to aquatic vegetation, or other appro-



Rainwater Killifish.

priate structures, and the eggs are then quickly fertilized by the male. Eggs hatch in 6 to 14 days, depending on water temperature. The diet of Rainwater Killifishes is comprised of a variety of small aquatic invertebrates, including mosquito larvae and crustaceans.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Rainwater Killifish are common in many of the drainages to Nantucket Sound and to Buzzards and Narragansett bays. They are common in the tidal freshwaters of Martha's Vineyard, where they are also found in a freshwater pond at Felix Neck. Rainwater Killifish seem to be rare on Nantucket, where the first records were brought to our attention by B. Stallsmith in 1995.

NOTES. Hubbs and Miller (1965:35–36) state that "...the most trenchantly distinct of the local forms [of *L. parva*] inhabits southern New England" and "...Were it not for the irregularity in the clines, this New England race would warrant separation as the nominate subspecies." They point out that similar patterns of differentiation have been noted for southern New England populations of Sheepshead Minnow, silversides, and Hogchoker.

REFERENCES. Hardy 1978 (development, review); Hubbs and Miller 1965 (description, distribution, systematics, variation); Moyle 1976 (general biology); Beck and Massmann 1951 (movement); Stallsmith 1997 (Nantucket).

Silverside Family

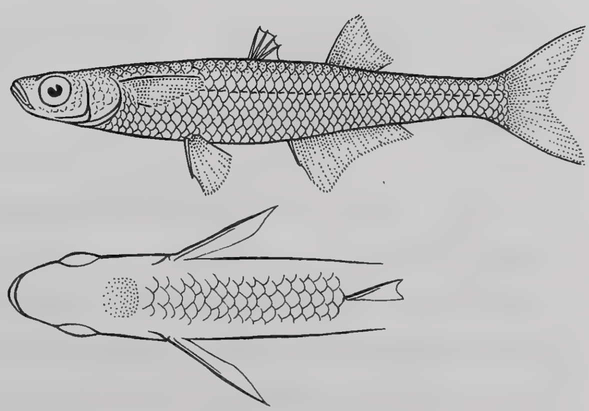
Atherinopsidae

The silverside family, formerly called the Atherinidae, consists of small fishes, usually less than 8 inches in total length, that are widely distributed throughout tropical and temperate regions of the world. They are related to the killifishes and pupfishes (Fundulidae and Cyprinodontidae). Silversides inhabit marine, brackish, and freshwaters. Some species inhabit Andean lakes, and one species, the Brook Silverside, *Labidesthes sicculus,* is common in freshwaters of the central and southeastern United States with its northeastern limit in New York. As their common name indicates, atherinopsids are silvery, and somewhat translucent, with a distinct, silver midlateral band. They have two dorsal fins; the first is small, inconspicuous, and separated from the second. The lateral line is reduced or absent, and the pelvic fins are located approximately at midbody. Silversides have small mouths with fine teeth. They often school in large numbers. In many parts of the world, silversides are fried whole or dried for human consumption and are often called "whitebait."

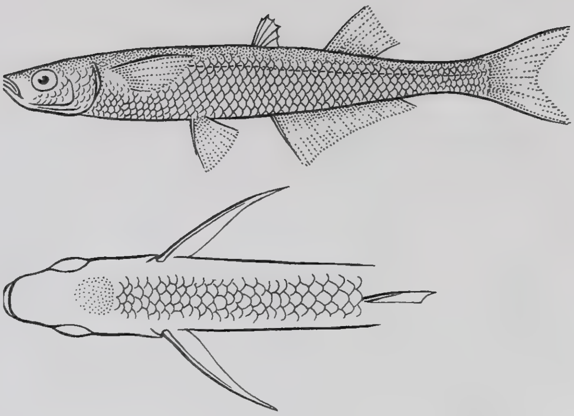
REFERENCES. Bigelow and Schroeder 1953 (MA); Chernoff et al. 1981, Dyer and Chernoff 1996 (systematics); Gosline 1948 (speciation); Johnson 1975, Parenti 1993 (relationships).

Key to Massachusetts Silversides

1a. Predorsal scales fewer than 16; anal fin rays usually fewer than 18. Inland Silverside, *Menidia beryllina,* page 212, Plate 53.



1b. Predorsal scales usually more than 20; anal fin rays usually more than 22. Atlantic Silverside, *Menidia menidia*, page 214, Plate 53.

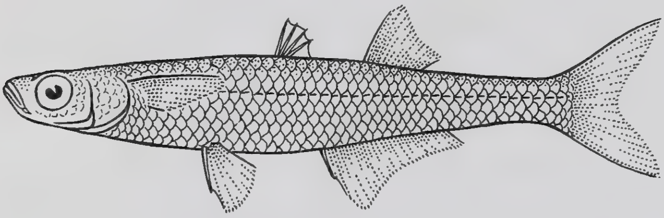


Inland Silverside

Native

Menidia beryllina (Cope 1866)

PLATE 53

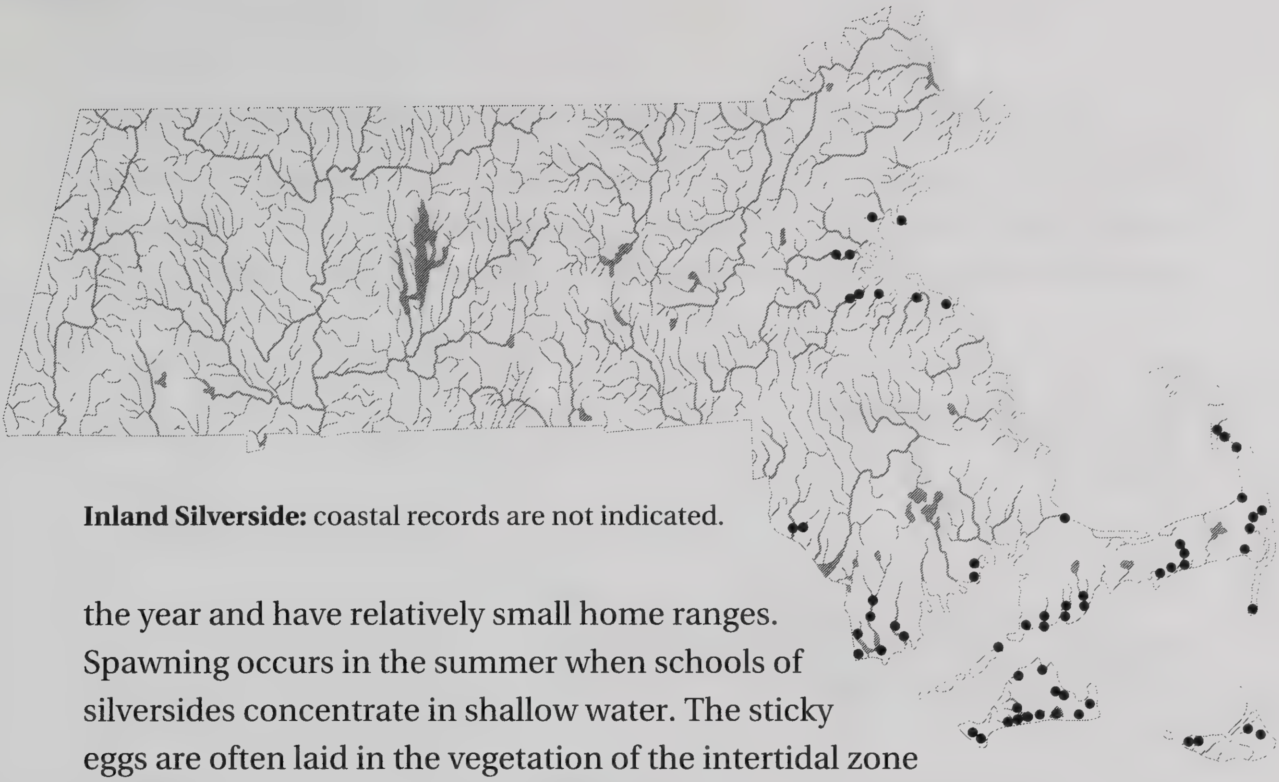


IDENTIFICATION. Silversides are silvery fishes with two dorsal fins and one weak anal spine. Inland Silversides are similar to Atlantic Silversides but have shorter anal fins and larger scales. Inland Silversides have fewer than 16 predorsal scales and 15 to 16 (rarely 20) anal rays. They are a light silver green to waxen yellow dorsally with a well-defined midlateral silver stripe. The dorsal and caudal fins are occasionally washed with orange.

SELECTED COUNTS. D IV–VII, 8–10; A I,13–19; Scales 36–42.

SIZE. Inland Silversides are smaller than the Atlantic Silversides and rarely reach 4 inches TL. The largest Massachusetts specimens that we have examined measure just over 3 inches TL (67 mm SL).

NATURAL HISTORY. In Massachusetts, Inland Silversides are frequently found in bays, salt marshes, estuaries, coastal freshwater, and overwash ponds. They commonly enter areas of freshwater above the influence of the tides but rarely travel far upstream. Inland Silversides are often found with Atlantic Silversides and usually outnumber them in less saline areas. They are commonly found in large schools that remain in the estuaries most of



Inland Silverside: coastal records are not indicated.

the year and have relatively small home ranges. Spawning occurs in the summer when schools of silversides concentrate in shallow water. The sticky eggs are often laid in the vegetation of the intertidal zone at high tide. These eggs quickly sink and adhere to the vegetation or sandy bottom. The eggs hatch in one to two weeks, depending on water temperature. The juveniles become mature at one year. Diet is varied and a wide range of plant and animal material is eaten, including zooplankton, shrimp, amphipods, mollusks, worms, larval fishes, fish eggs, and, to a lesser extent, algae and detritus.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, the Inland Silverside is most commonly found in the coastal streams, bays, and estuaries on the south side of Cape Cod. North of Pleasant Bay on the outer arm of Cape Cod, Inland Silversides are much less abundant but may be expected in most of the bays and estuaries south of Nahant. Bigelow and Schroeder (1953) found only one record from north of the Cape, but we found that Inland Silversides were common to abundant in the Massachusetts Bay area, including the Charles River in Cambridge and Boston during the mid- to late 1970s. However, recent surveys (1983–1997) in the Charles River have not found this species. The abundance north of Cape Cod may be cyclic, expanding or contracting depending on environmental factors.

NOTES. This species has also been variously called the "waxen" or "tidewater" silverside. A southern New England subspecies, *M. b. cerea,* has been described, but its status has not been recently reviewed.

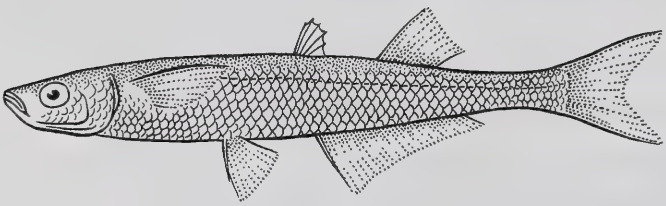
REFERENCES. Bengtson 1985, Middaugh et al. 1986 (reproduction); Bigelow and Schroeder 1953 (general biology); Collette and Hartel 1988 (Massachusetts Bay); Kendall 1902, Johnson 1975, Chernoff et al. 1981 (systematics); Korth and Fitzsimons 1987 (karyotype); Hoff 1972 (movement, MA).

Atlantic Silverside

Native

Menidia menidia (Linnaeus 1766)

PLATE 53

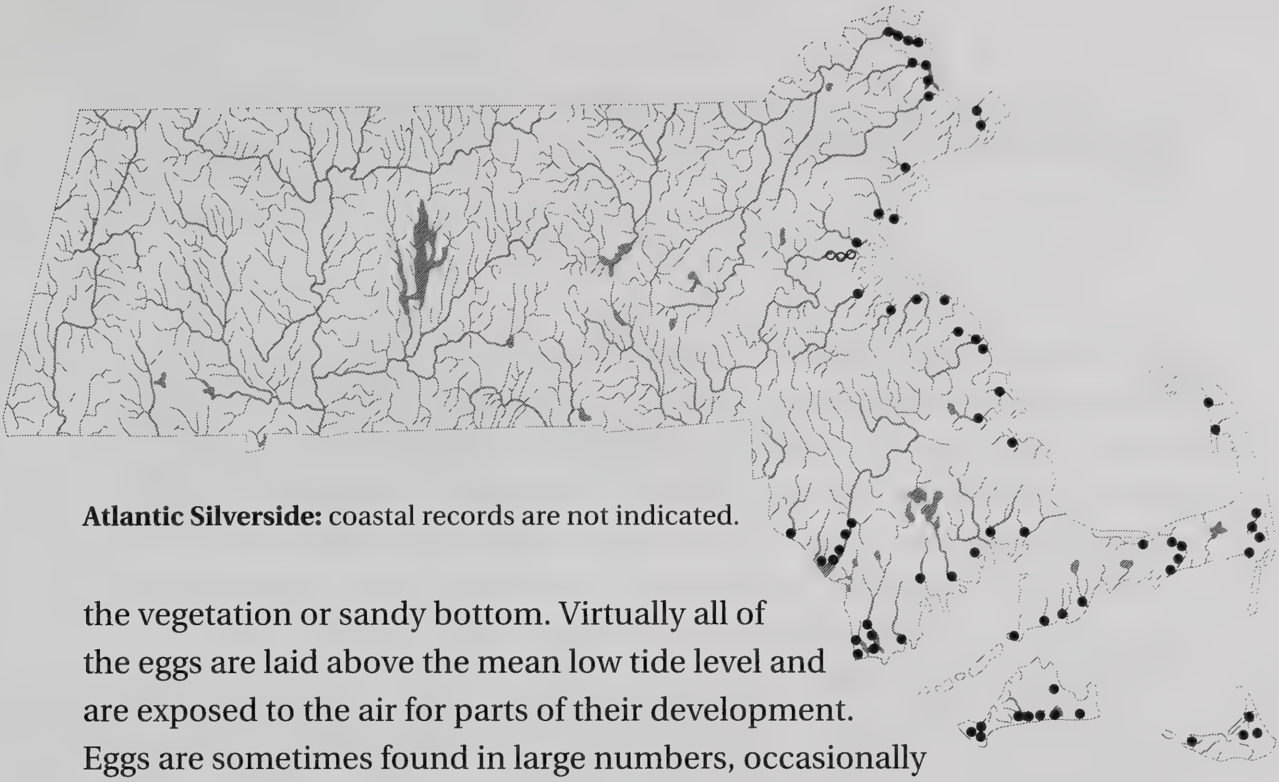


IDENTIFICATION. Silversides are silvery fishes with two dorsal fins and one weak anal spine. Atlantic Silversides are similar to Inland Silversides but have longer anal fins and smaller scales. Atlantic Silversides usually have more than 20 crowded predorsal scales and 22 to 25 anal rays. They are a silver-green dorsally and have a well-defined midlateral silver stripe.

SELECTED COUNTS. D III–VII,7–11; A I,19–29; Scales 43–55.

SIZE. Atlantic Silversides commonly reach 4.5 inches TL, and individuals up to 5.5 inches TL have been recorded.

NATURAL HISTORY. Atlantic Silversides are inshore marine fishes that are frequently found in bays, salt marshes, and estuaries but only rarely enter areas of freshwater above the influence of the tides. They are commonly found in large schools in areas of sandy bottoms and aquatic vegetation. Silversides often congregate in shallows, particularly when high tides have partially submerged the shore vegetation. In winter, most silversides move into deeper water, but some may survive in shallow water under the ice. Winter mortality is occasionally high as large winter die-offs have been reported. In Massachusetts, protracted spawning occurs from mid-May to late July and eggs are often laid in the vegetation of the intertidal zone, usually at high tide. The eggs, which have tufts of filaments, sink and adhere to



Atlantic Silverside: coastal records are not indicated.

the vegetation or sandy bottom. Virtually all of the eggs are laid above the mean low tide level and are exposed to the air for parts of their development. Eggs are sometimes found in large numbers, occasionally forming large sheets and clusters. The eggs hatch in one to two weeks, depending on water temperature, and the young mature at one year. Most Atlantic Silversides in Massachusetts die before they reach two years of age. Diet is varied; Atlantic Silversides eat a wide range of plant and animal material.

DISTRIBUTION AND ABUNDANCE. Atlantic Silversides are found along the Atlantic coast of North America from the Gulf of Saint Lawrence to northern Florida. In Massachusetts, this species is common to abundant along virtually the entire coast. However, the abundance of Atlantic Silversides may be cyclic and is also linked to the availability and health of salt marshes.

NOTES. Like the Inland Silverside, the Atlantic Silverside is an important forage fish and is readily eaten by game fishes, such as the Bluefish, *Pomatomus saltatrix,* and the Striped Bass. It is also heavily preyed upon by birds, particularly terns and herons, when the silversides congregate in shallow water. Atlantic Silversides are a popular, but soft, bait fish.

REFERENCES. Bigelow and Schroeder 1953, Clayton et al. 1978 (review, MA); Bengtson et al. 1987 (reproduction); Conover 1979, 1982, Conover and Ross 1982 (biology, MA); Middaugh 1981 (reproductive ecology).

Mullet Family

Mugilidae

Mullets are primarily marine fishes that are found worldwide in inshore tropical and temperate waters. Many species regularly enter rivers and streams, and some spend their entire lives in freshwater. Fishes of this family often form loose schools and feed in bays and estuaries. They have a specialized pharyngeal organ and a long, coiled gut that allows them to process their food. Diet is variable, but plant material and detritus are often ingested. In some regions, mullets are commercially important fishes.

Recently the relationships of the mullets have been studied in depth, and although there is some disagreement all reviewers agree that they are closely related to the atherinoids. Of the 70 or so species, only two are found as far north as New England. One, the Striped Mullet, frequently enters the freshwaters. The other species, the White Mullet, *Mugil curema,* is similar but seldom enters freshwater. The two species can be separated by the following key.

REFERENCES. Stiassny 1993, Nelson 1994 (relationships); Harrison and Howes 1991 (pharyngeal organ).

Key to Massachusetts Mullets

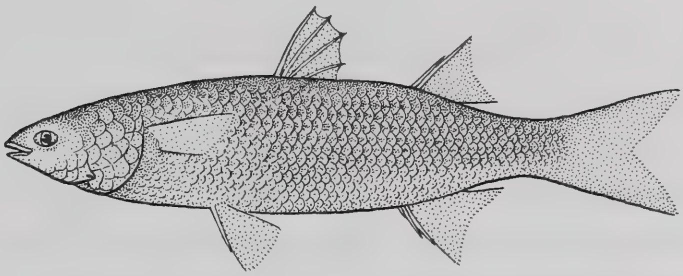
1a. Anal fin with 11 elements, 3 spines and 8 rays in adults, 2 spines and 9 rays in juveniles less than 40 mm SL; scales usually absent from second dorsal and anal fins (not illustrated). Striped Mullet, *Mugil cephalus,* page 217.

1b. Anal fin with 12 elements, 3 spines and 9 rays in adults, 2 spines and 10 rays in juveniles less than 40 mm SL; second dorsal and anal fins with rows of scales (not illustrated). White Mullet, *Mugil curema.* See comments under Striped Mullet.

Striped Mullet

Native

Mugil cephalus (Linnaeus 1758)

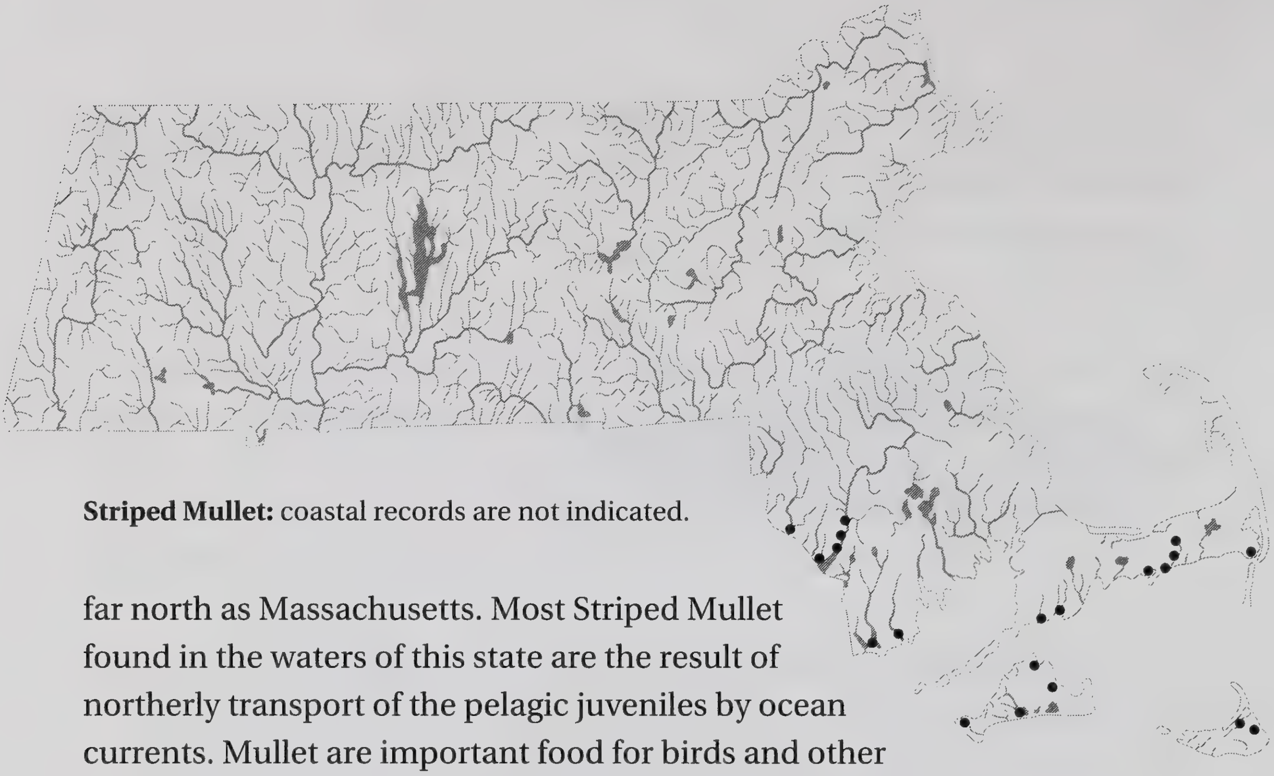


IDENTIFICATION. Juvenile mullets are similar in appearance to adult silversides (Atherinopsidae). The anal fin of the Striped Mullet has many fewer rays than those of silversides; there are fewer than 9 in mullets and more than 12 in silversides. The origin of the anal fin is directly below or behind the origin of the second dorsal fin in the mullet, while it is anterior to the origin of the dorsal fin in silversides. The White Mullet can be distinguished from the Striped Mullet by the characters in the key (anal counts, dorsal and anal fin scales) and the fact that fresh adult Striped Mullet have stripes along the body. The sides and belly of the Striped Mullet are silvery white, and the upper surfaces of the body a darker blue grey. The young are often bright silvery.

SELECTED COUNTS. D IV, I,8; A III–8

SIZE. Striped Mullet are usually around 20 inches long (450 to 550 mm SL), though specimens as large as 2 feet have been recorded (622 mm SL). Males are usually slightly smaller than females.

NATURAL HISTORY. Striped Mullet are an inshore marine species, and small schools are frequently found in bays, estuaries, and coastal streams. Diet consists of small invertebrates, zooplankton, and detritus. Mouthfuls of substrate are scooped from the bottom and are handled with the pharyngeal organ and a specialized gizzard. As is typical with many detritivores, food is processed in a long coiled intestine. Mullets are nocturnal spawners in areas up to 40 to 50 miles offshore and have pelagic larvae and postlarvae that return to coastal waters. Spawning is probably uncommon in waters as



Striped Mullet: coastal records are not indicated.

far north as Massachusetts. Most Striped Mullet found in the waters of this state are the result of northerly transport of the pelagic juveniles by ocean currents. Mullet are important food for birds and other fishes.

DISTRIBUTION AND ABUNDANCE. The Striped Mullet has a cosmopolitan distribution and is found in virtually all the temperate and tropical inshore areas of the world. In the western North Atlantic, this species has been recorded as far north as Nova Scotia but is not usually common north of Cape Cod. Indeed, most of the previous identifications of Striped Mullet north of Cape Cod are thought to be White Mullet (Scott and Scott 1988). However, several hundred Striped Mullet were reported in the vicinity of the Pilgrim Nuclear Generating Station and in other areas of Massachusetts Bay during November and December 1975. In Massachusetts, Striped Mullet are frequently encountered during the summer months in bays, estuaries, and freshwater coastal rivers and streams draining the south side of Cape Cod and the Islands.

NOTES. Striped Mullet are raised in brackish ponds for human consumption in many parts of the world and have been extensively studied.

REFERENCES. Bigelow and Schroeder 1953, Scott and Scott 1988 (old and new records); Fairbanks and Lawton 1977 (Mass. Bay records); Stiassny 1993 (relationships); Thompson 1963, 1997 (biology, nomenclature).

Stickleback Family

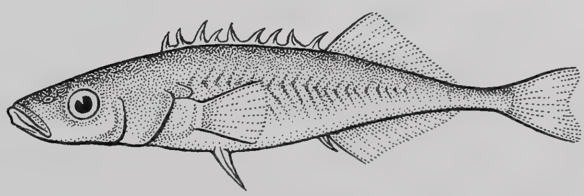
Gasterosteidae

Sticklebacks are found in temperate marine and inland waters of the Northern Hemisphere. The family has about five genera and nine species. Sticklebacks show so many inter- and intra-populational differences in morphology and behavior that just one species has been described as more than 40 different species. Male sticklebacks are brightly colored during breeding season and build a nest out of aquatic vegetation using kidney secretions. They actively court females, enticing them to the nests with a series of highly complex and species-specific displays. Each nest may contain the eggs of several different females. Males aggressively guard the nests and care for the eggs and newly hatched young. Sticklebacks have been well studied in relation to evolution, ecology, ethology, physiology, reproduction, and endocrinology.

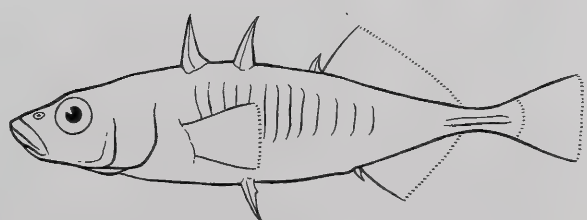
REFERENCES. McLennan et al. 1988 (behavior/relationships); Wootton 1976 (summary of family); Fitzgerald 1983 (reproduction/behavior); Tinbergen 1952 (behavior); Wootton 1984 (general biology).

Key to Massachusetts Sticklebacks

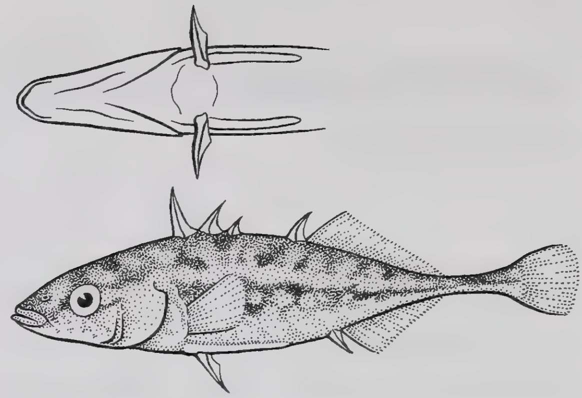
1a. Usually 8 or more short, alternately inclined dorsal spines, body elongate. Ninespine Stickleback, *Pungitius pungitius,* page 227, Plate 52.



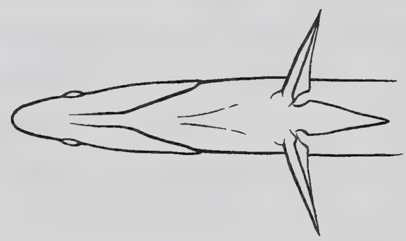
1b. Less than 8 medium to long dorsal spines, body moderately deep. Go to 2.



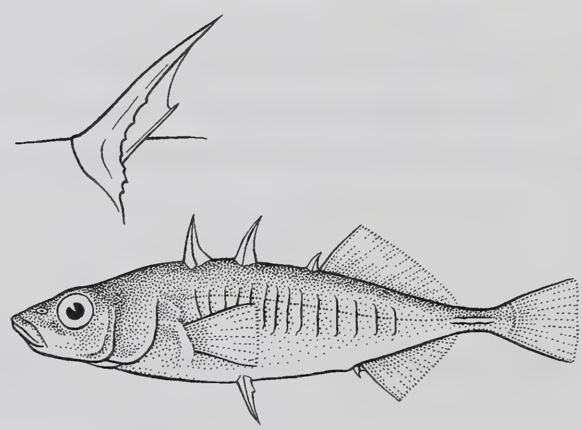
2a. Pelvic skeleton shows externally as a pair of ventro-lateral keels. Fourspine Stickleback, *Apeltes quadracus,* page 221, Plate 49.



2b. Pelvic skeleton with a single median posterior extension. Go to 3.



3a. Pelvic fin with 1 small soft ray; pelvic spine lacking ventral cusp (ventral view shown); usually with bony lateral keel on caudal peduncle; always lacks spots on flanks. Threespine Stickleback, *Gasterosteus aculeatus,* page 223, Plate 50.



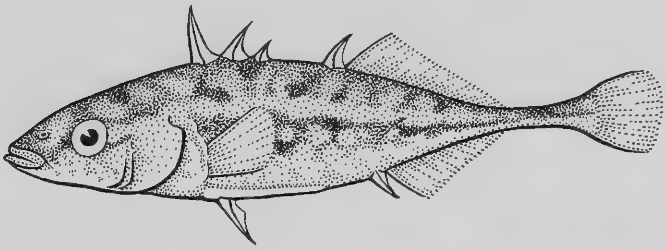
3b. Pelvic fin usually with 2 small soft rays; pelvic spine with well-developed ventral cusp (ventral view shown); always lacks bony lateral keel on caudal peduncle; dark spots usually present on flanks. Blackspotted Stickleback, *Gasterosteus wheatlandi,* page 225, Plate 51.

Fourspine Stickleback

Native

Apeltes quadracus (Mitchill 1815)

PLATE 49



IDENTIFICATION. Fourspine Sticklebacks have two ventro-lateral processes of the pelvic girdle (see key Figure 2a) and usually have four or five dorsal spines. They are olive-brown dorsally with dark irregular markings, and the belly and breast are white to silver in color. Males become much darker and the pelvic fins turn bright red during the breeding season.

SELECTED COUNTS. D IV–V,11–12; A I,9–11; Pel I,2.

SIZE. The Fourspine Stickleback is a small fish with adults rarely reaching 2.5 inches TL.

NATURAL HISTORY. Fourspine Sticklebacks are found primarily in salt marshes and tidal creeks. They seasonally enter freshwater and may be found considerable distances upstream. Fourspine Sticklebacks move into fresh and brackish waters from May to July, and the males build small nests out of aquatic vegetation. These nests are constructed well above the bottom by gluing pieces of aquatic vegetation and detritus with a special kidney secretion. Males actively court any female that swims by the partially completed nest. If the female is receptive, she burrows into the top of the nest and deposits adhesive eggs. Each female lays approximately 35 eggs; however, the number varies with the age and size of the female. After fertilizing the eggs, the male chases the female away and frequently builds several more nests on top of the original nest. The males tend and defend the eggs and young. In most populations, the males live only one year, while females may live up to three years. Diet includes a wide variety of small aquatic invertebrates, particularly amphipods, isopods, dipterans, and zooplankton as well as aquatic vegetation.

Fourspine Stickleback: coastal records are not indicated.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Fourspine Sticklebacks are found in estuaries along the entire coast and are common in some freshwater streams and ponds in the Cape Cod, Buzzards Bay, and Narragansett Bay drainages, and on Martha's Vineyard. They are found as far inland as Haverhill on the Merrimack River.

NOTES. The Fourspine Stickleback has been observed removing and eating external parasites from the Rainwater Killifish. This behavior is called a cleaning symbiosis and has been noted in a number of fish species.

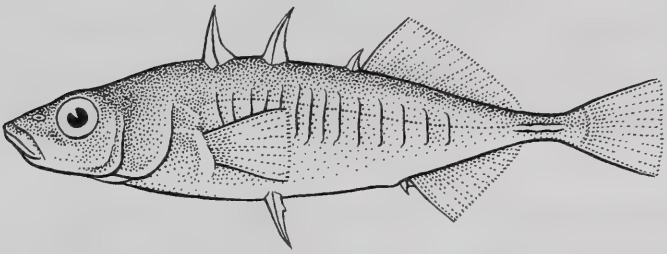
REFERENCES. Bigelow and Schroeder 1953 (general); Schwartz 1965 (life history); Baker 1971 (habitat preference); Krueger 1961, Blouw and Hagen 1987 (morphological variation); Reisman 1963 (reproduction); Rowland 1974a, 1974b (reproduction); Tyler 1963 (cleaning symbiosis); Wootton 1976, 1984 (reviews).

Threespine Stickleback

Native

Gasterosteus aculeatus Linnaeus 1758

PLATE 50



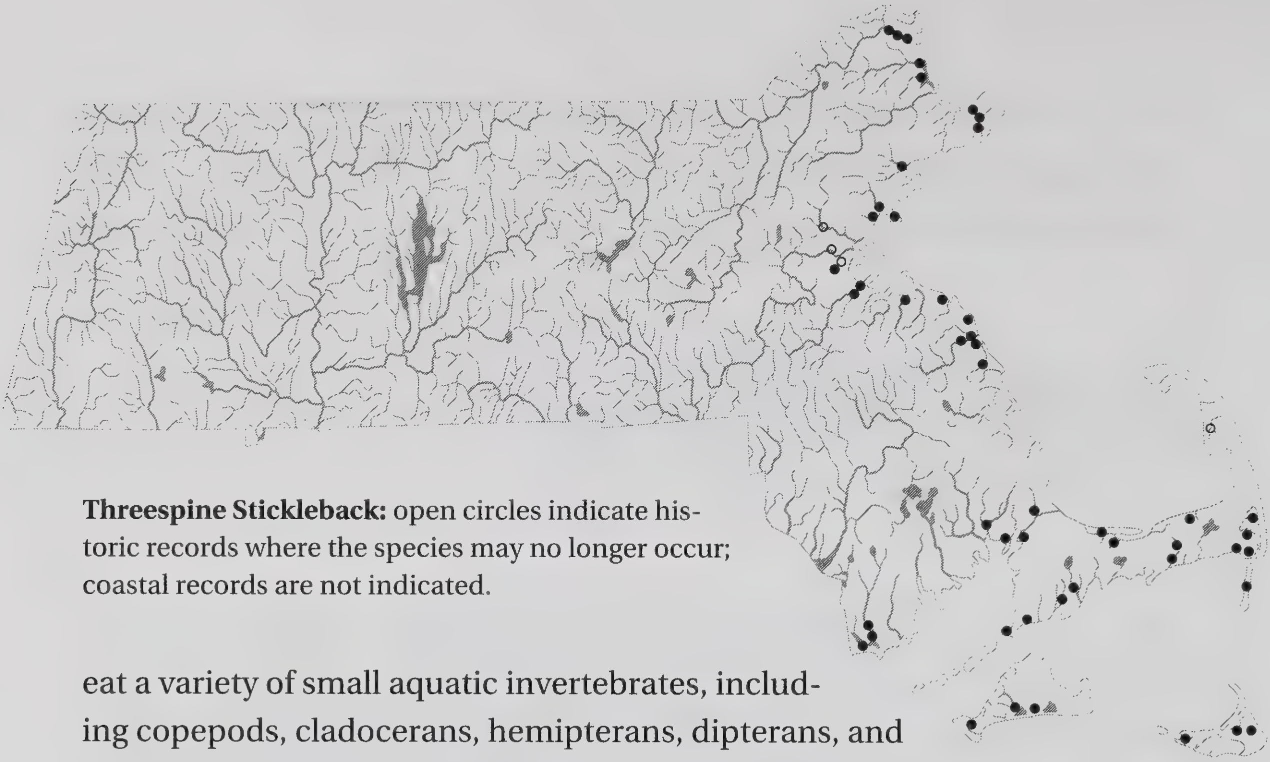
IDENTIFICATION. Similar to Blackspotted Sticklebacks, Threespine Sticklebacks have only one small pelvic ray and lack well-developed ventral cusp on the pelvic spine (see key Figure 3a). A lateral keel on the caudal peduncle is typically present in the Threespine Stickleback but may be absent in inland populations. Threespine Sticklebacks are drably colored, varying from a silver yellow to light brown and green except during the breeding season, when the overall color of the male darkens and the breast and belly become a bright red with the eyes turning vivid light blue.

SELECTED COUNTS. D III,9–11; A I,9–11; Pel I,1.

SIZE. Marine Threespine Sticklebacks commonly reach 2 to 3 inches TL. Individuals of Massachusetts' only known landlocked population are smaller, typically ranging from 1 to 1.5 inches TL.

NATURAL HISTORY. In Massachusetts, Threespine Sticklebacks typically occur in marine environments and move toward freshwater during the spring and early summer spawning season. They are commonly encountered in estuaries, salt marshes, and the tidal portions of rivers and streams. At the beginning of the spawning season, males construct small, barrel-shaped nests of vegetation and detritus on the bottom. Females are attracted to the nests by an elaborate courtship display known as the "zigzag" dance. Males may mate with several females, and individual nests may contain up to 600 eggs. Care of the eggs and young is left to the males.

The life span of the Threespine Stickleback is variable between populations; some individuals live only a single year, and others up to 3.5 years. They become mature at one to three years of age. Threespine Sticklebacks



Threespine Stickleback: open circles indicate historic records where the species may no longer occur; coastal records are not indicated.

eat a variety of small aquatic invertebrates, including copepods, cladocerans, hemipterans, dipterans, and ostracods. Aquatic plants, larval fishes, fish eggs, and mollusks are also frequently eaten. However, the specific diet is highly dependent on the type of habitat in which the stickleback is living and the seasonal abundance of prey.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Threespine Sticklebacks are found along the entire coast in estuaries, salt marshes, and tidal creeks. The Threespine Stickleback is often abundant in coastal waters of low salinity during the spring and summer spawning season. The only landlocked population is located in Boston's Olmsted Park.

NOTES. The landlocked population of Threespine Sticklebacks in Olmsted Park (which forms the boundary between Boston and Brookline) is unique for several reasons. The population has three distinct lateral-plate morphs, low numbers of plates without a caudal keel, intermediate numbers of plates, or is completely plated. Most Olmsted Park individuals are the complete or low lateral-plate morphs. In eastern North America, this population represents only the fourth record of low plate individuals and is the southernmost completely freshwater population. This population has been isolated from the Charles River Basin estuarine population only since the late 1800s. Within their small range (225-square-yard pool and outflow), these animals are common but are susceptible to extinction due to their urban habitat. The population is currently listed as Threatened by the Massachusetts Division of Fisheries and Wildlife. It is possible that this population

was introduced to the pools because the area was planned to be part of a natural history museum complex by Frederick Law Olmsted (never-completed), and he had designated one of the pools to exhibit sticklebacks.

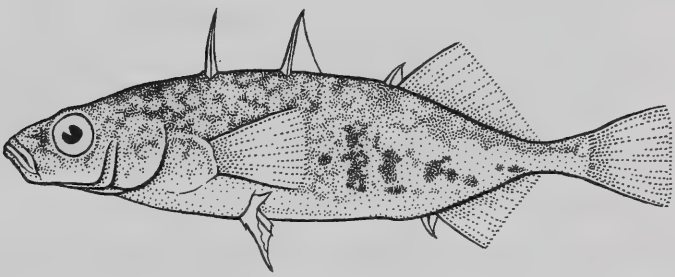
REFERENCES. Bell and Foster 1994, Wootton 1976, 1984 (biology, review); Bell and Baumgartner 1984 (Boston, freshwater population); Coad 1983 (Canada, freshwater populations); Coad and Power 1973 (ecology).

Blackspotted Stickleback

Native

Gasterosteus wheatlandi Putnam 1867

PLATE 51

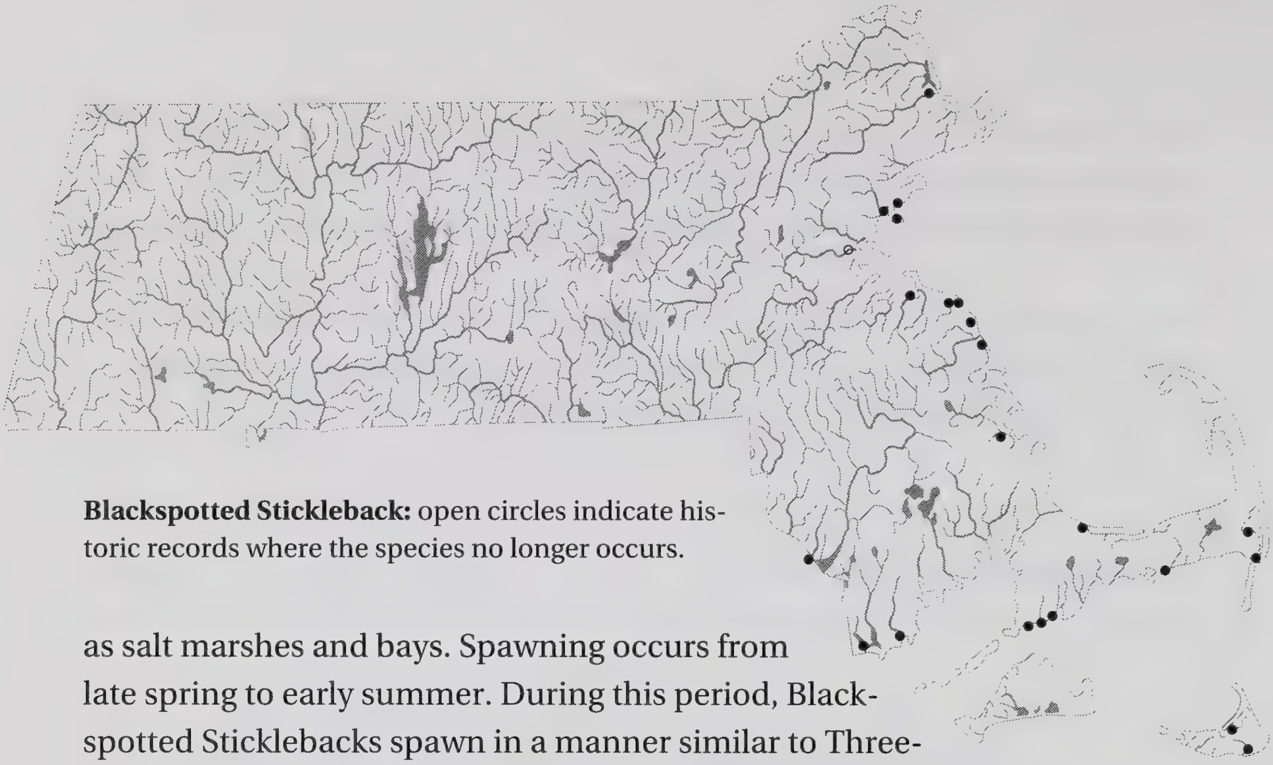


IDENTIFICATION. Blackspotted and Threespine Sticklebacks are similar, but Blackspotted Sticklebacks usually have two small pelvic rays and always lack the lateral keel on the caudal peduncle. They have well-developed ventral cusps at the base of the pelvic fin spine (see key Figure 3b). Blackspotted Sticklebacks are usually light silver-white with only a faint hint of black spots along the sides of the body. During spawning, the body and unpaired fins become yellow-green, and the dark spots on the sides of the body and head are obvious.

SELECTED COUNTS. D III, 9–10; A I, 6–8; Pel I,1–3.

SIZE. The Blackspotted Stickleback is a small species; individuals over 2 inches TL are seldom observed.

NATURAL HISTORY. Blackspotted Sticklebacks are the most marine of the Massachusetts sticklebacks. They are found from estuaries to well offshore. They occasionally move upstream but rarely so far as to enter freshwater. Blackspotted Sticklebacks normally remain in brackish environments, such



Blackspotted Stickleback: open circles indicate historic records where the species no longer occurs.

as salt marshes and bays. Spawning occurs from late spring to early summer. During this period, Blackspotted Sticklebacks spawn in a manner similar to Threespine Sticklebacks. Variations in their reproductive dance sequences serve to isolate these species and prevent hybridization. Blackspotted Sticklebacks apparently spawn at one year, and most die shortly thereafter. Females have been found to carry approximately 70 to 160 eggs. The diet of this species is poorly known but probably consists of aquatic invertebrates and juvenile fishes.

DISTRIBUTION AND ABUNDANCE. The Blackspotted Stickleback has the smallest range of any of the American stickleback species. It is found only from Newfoundland south to New York. In Massachusetts, the Blackspotted Stickleback lives along the entire coast. Freshwater populations are unknown in Massachusetts; however, these fish are abundant in areas of low salinity in Sesachacha Pond, Nantucket.

NOTES. This species was described by Harvard University's anthropologist and natural historian, F.W. Putnam, from specimens collected at Nahant, Massachusetts. The species is named after R.H. Wheatland, one of the early naturalists at the Essex Institute in Salem.

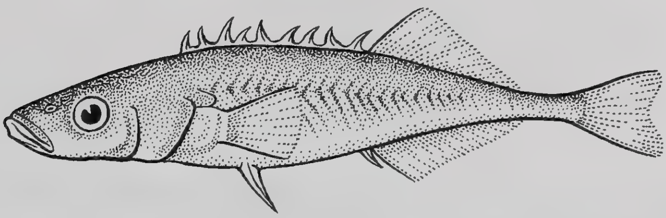
REFERENCES. Bigelow and Schroeder 1953, Scott and Crossman 1973 (general); Coad and Power 1973 (ecology); Reisman 1968, McInerney 1969 (reproduction); Sargent et al. 1984 (plate variations); Wootton 1976 (general biology).

Ninespine Stickleback

Native

Pungitius pungitius (Linnaeus 1758)

PLATE 52

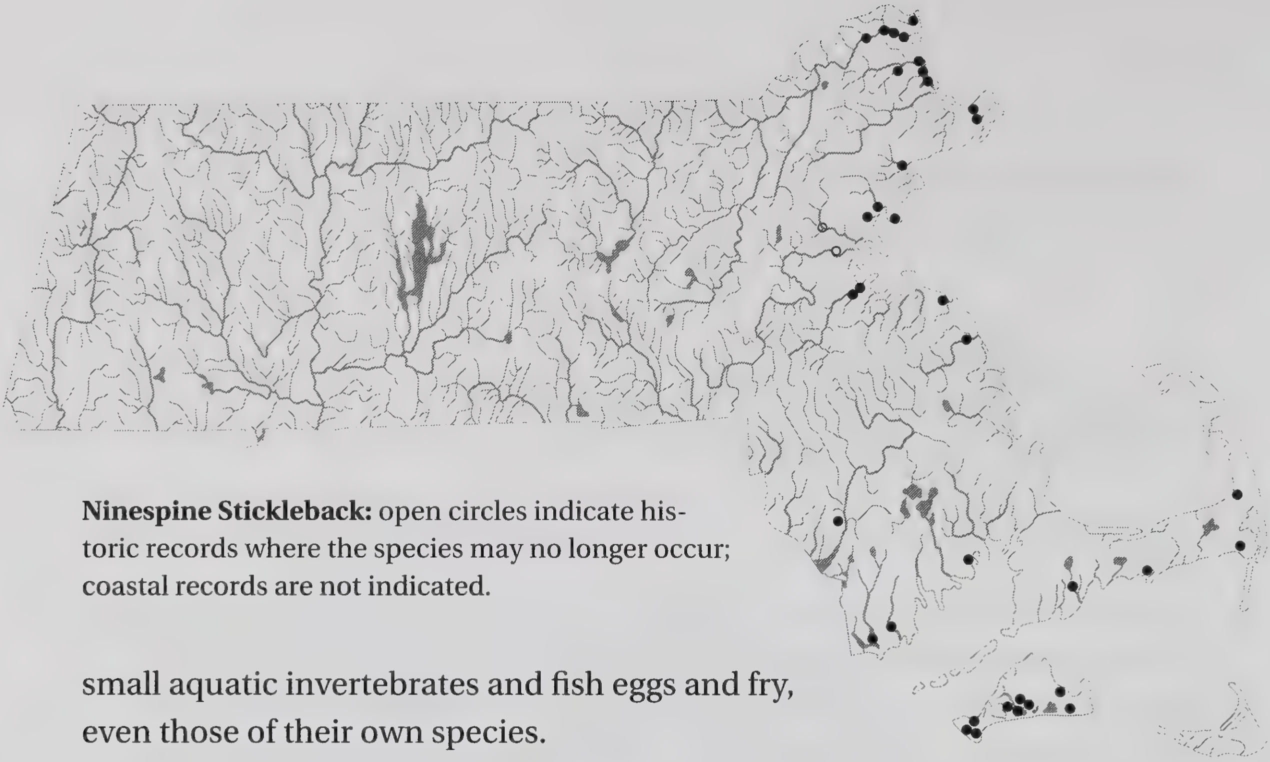


IDENTIFICATION. Ninespine Sticklebacks have an elongate body and usually 8 to 11 short dorsal spines that fold alternately from one side to the other when collapsed. The upper body of the Ninespine Stickleback is a light olive-green with irregular dark markings. The belly and breast are a lighter silvery-yellow to white. Males darken considerably during breeding season, and their pelvic fin spines turn white.

SELECTED COUNTS. D VIII–XI(VI–XIII),9–11; A I,8–10; Pel I,1.

SIZE. Ninespine Sticklebacks are generally small fishes; in our recent collections we have seldom seen specimens over 2 inches TL. However, in a series of MCZ specimens collected between 1856 and 1859 from Salem Mill Pond, the adults range up to 3.5 inches TL (71 mm SL).

NATURAL HISTORY. In Massachusetts, Ninespine Sticklebacks are found in salt marshes and coastal streams. They are often associated with well-vegetated freshwater or slightly brackish areas, particularly during the late spring to summer spawning season. Small, tunnel-shaped nests are constructed by males from aquatic vegetation and are usually built well above the bottom. Females are attracted to the nests by a series of courtship displays. If these displays are successful, the female will enter the nest and deposit 30 to 40 eggs. Gravid females contain up to 140 eggs. The eggs in the nest are quickly fertilized by the male, and the female is chased away. Males may mate with up to seven females in each nest and may construct several nests. Males tend the eggs and young until the young are 0.25 to 0.5 inches long. Individuals of this species become mature at one year and may live to be 3.5 years. Ninespine Sticklebacks are known to eat a wide variety of



Ninespine Stickleback: open circles indicate historic records where the species may no longer occur; coastal records are not indicated.

small aquatic invertebrates and fish eggs and fry, even those of their own species.

DISTRIBUTION AND ABUNDANCE. Massachusetts populations of the Ninespine Stickleback are often found in estuaries and salt marshes. Coastal freshwater populations seem to be more common in the streams of the Southern New England Drainage Area. There is at least one completely landlocked population on Martha's Vineyard. Ninespine Sticklebacks are often numerous, but they are found far less frequently than the other sticklebacks.

NOTES. The relationships of the many forms of the Ninespine Stickleback in North America and Eurasia are still in question. Like other sticklebacks, this species is polymorphic in lateral plate numbers and placement. In the Ninespine Stickleback, the lateral plates can be complete, partial, or found only on the caudal keel. Haglund et al. (1992) suggest that the name *Pungitius occidentalis* (Cuvier) be applied to the North American population.

REFERENCES. Griswold and Smith 1973 (life history); Fitzgerald 1983 (ecology and behavior); Ayvazian and Krueger 1992 (lateral plates); Wootton 1976 (general biology); Haglund et al. 1992 (relationships).

Pipefish and Seahorse Family

Syngnathidae

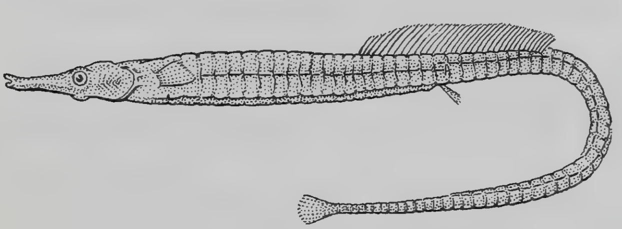
The seahorse and pipefish family is primarily marine, but a number of species live in freshwater and many others occasionally enter freshwater streams. Seahorses and pipefishes have a worldwide distribution in tropical and temperate waters. There are approximately 215 species in the family; one, the Northern Pipefish, is common in the inshore marine waters of Massachusetts and occasionally occurs in tidal freshwater. The syngnathids have elongate bodies that are covered with a series of interlocking, bony plates, and their heads and snouts are roughly tubular, ending in a small mouth. Males carry the fertilized eggs and maturing larvae in a brood pouch until the young are well developed. The young are expelled from the brood pouch by the body contractions of the male.

REFERENCES. Dawson 1982 (review of western North Atlantic species).

Northern Pipefish

Native

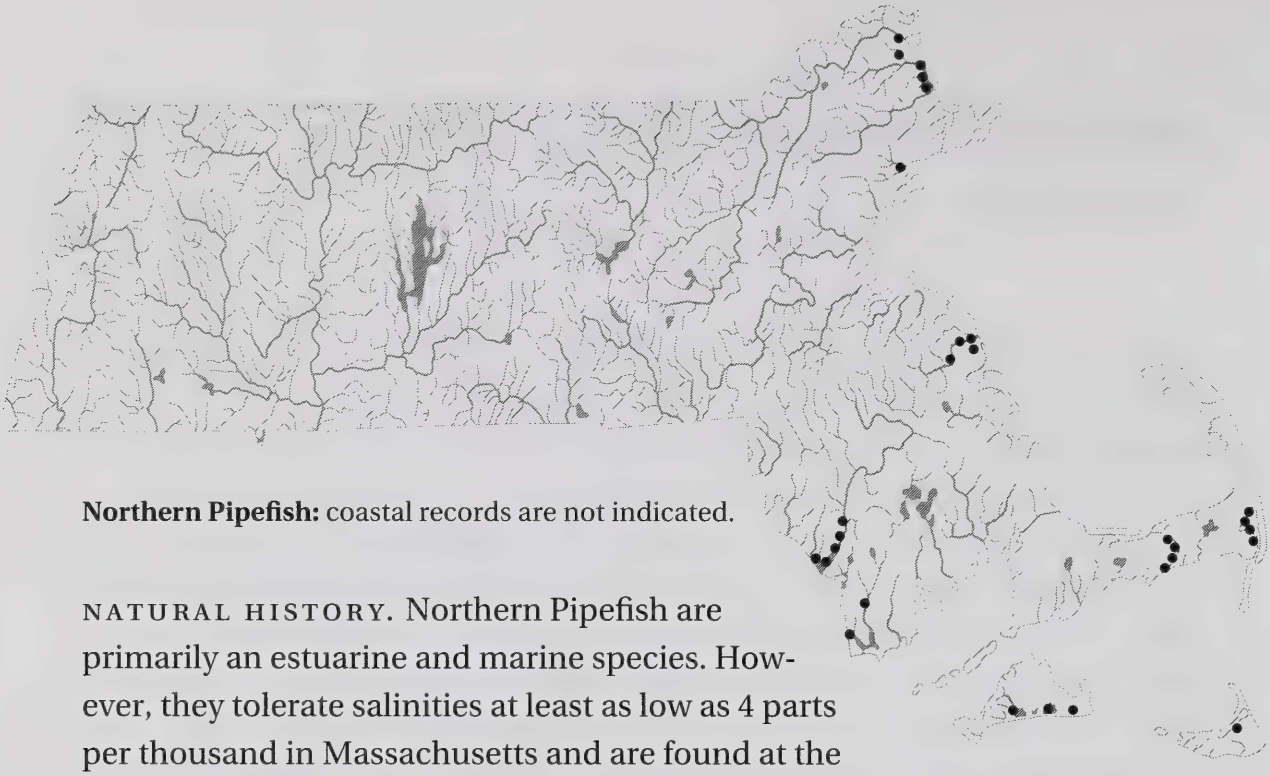
Syngnathus fuscus Storer 1839



IDENTIFICATION. Northern Pipefish have elongate bodies that are covered with interlocking bony plates. Pelvic fins are absent, and the snout is relatively long and tubelike. Color varies from a mottled brown to a light yellow-green.

SELECTED COUNTS. D 35–45; A 2–4.

SIZE. Northern Pipefish rarely exceed 10 inches in length, with 6- to 8-inch specimens being more common, especially in the upper portions of estuaries.



Northern Pipefish: coastal records are not indicated.

NATURAL HISTORY. Northern Pipefish are primarily an estuarine and marine species. However, they tolerate salinities at least as low as 4 parts per thousand in Massachusetts and are found at the heads of larger coastal estuaries. These pipefishes are often found in areas of dense aquatic vegetation, especially in eelgrass, *Zostera.* Although absent from Massachusetts estuaries during the winter months, Northern Pipefish start to become common in July and peak from August to October. It has been shown that they migrate inshore and offshore with the season, possibly to avoid colder estuarine temperatures.

DISTRIBUTION AND ABUNDANCE. Northern Pipefish are found along the Atlantic seaboard from Prince Edward Island, Canada, south to northern Florida. In Massachusetts, they are common in marine waters and may be expected to occur in the estuaries of most larger streams and rivers.

NOTES. The Northern Pipefish was first described by D.H. Storer in his first review of Massachusetts fishes in 1839, from a specimen collected at Nahant.

REFERENCES. Bigelow and Schroeder 1953, Collette and Hartel 1988 (general); Dawson 1982 (review); Fiske et al. 1968 (salinity); Lazzari and Able 1990 (migration).

Sculpin Family

Cottidae

The sculpins are a large family of fishes with more than 300 species in about 70 genera. This family belongs to the so-called "mail-cheek fishes," which have an armorlike, bony element that extends from the cheek to the preopercle. Although sculpins are mainly marine fishes of arctic and temperate seas, one-third of the cottid species occur in freshwater. Twenty-eight species of the genus *Cottus* are widely distributed in freshwater across North America. Deepwater Sculpin, *Myoxocephalus thompsoni,* live deeper than any other North American freshwater fish and have been found at depths of 1,000 feet in Lake Superior. Sculpins are a distinctive group of spiny fishes with morphological adaptations reflecting their bottom-living habits. They have broad, somewhat flattened heads with prominent, dorsally situated eyes, spines on the preopercle, and wide jaws with well-developed teeth. Their robust heads and bodies taper to a relatively narrow caudal peduncle. Scales are generally absent, although a few may be found along the lateral line in some species. The fin spines are soft and flexible, and the thin pelvic spine is inconspicuous since it is embedded in soft tissue. Sculpins have large, fan-like pectoral fins, and the small first dorsal fin is separated from the second dorsal fin by a distinct notch.

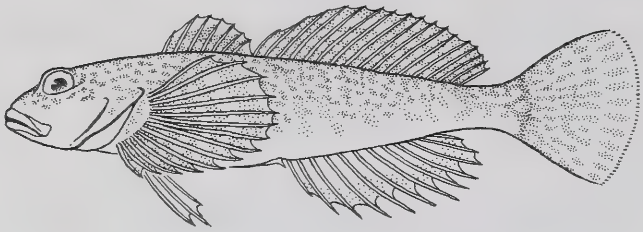
REFERENCES. Jenkins and Burkhead 1993 (review); Strauss 1989 (genetics and morphology); Washington et al. 1984a, 1984b (development, relationships).

Slimy Sculpin

Native

Cottus cognatus Richardson 1836

PLATE 54

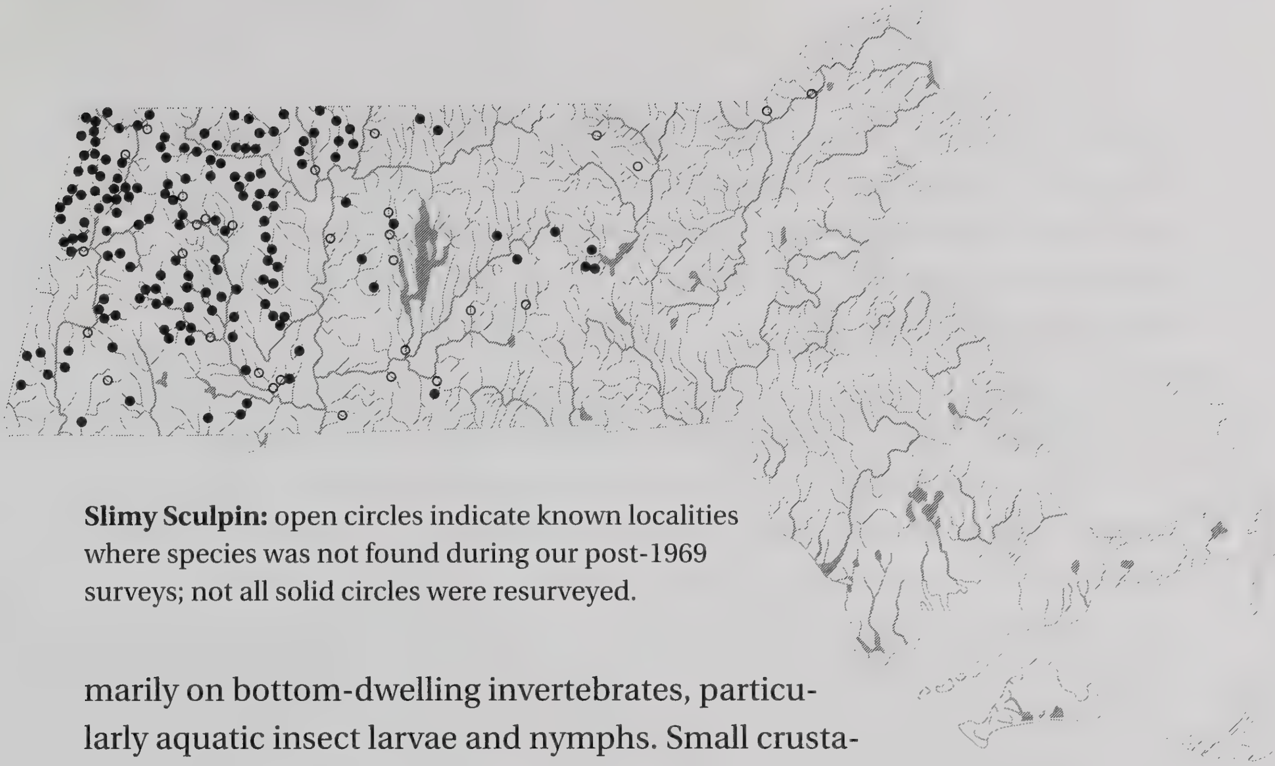


IDENTIFICATION. Sculpins have a broad head, tapering body, large fan-like pectoral fins, a hooked preopercular spine, no scales, pelvic fins positioned under the anterior base of the pectoral fins, and soft flexible fin spines. Slimy Sculpin are mottled brown to gray dorsally with saddle-shaped blotches that sometimes extend onto the upper sides. Breeding males are darker, almost black above, with a bright orange border on their first dorsal fin. This species is the only sculpin found in Massachusetts freshwaters. Another small sculpin, the Grubby, *Myoxocephalus aenaeus,* is common in local marine waters but never enters freshwater.

SELECTED COUNTS. D VI–IX+14–19; A 10–14; Pel I,3.

SIZE. Slimy Sculpin are relatively small fish; most adults are about 3 inches TL. We have seen an unusually large Slimy Sculpin, measuring 4.7 inches TL (96 mm SL), from a tributary to the Housatonic River in Pittsfield in 1979.

NATURAL HISTORY. In Massachusetts, Slimy Sculpin are known only from high gradient, rocky, clear, cold streams. In other parts of their range, they also inhabit cold-water lakes and low gradient spring-fed streams. In streams, Slimy Sculpin inhabit riffles and tend to stay close to the bottom, generally hidden in the stony substrate. Spawning takes place in the spring when water temperatures approach 50°F. Nests have been found in western Massachusetts in early May. Males establish territories around a crevice beneath a log, rock, or tree root. As one or more females are enticed into the nest, the eggs are deposited in a cluster on the underside of the roof of the nest cavity and are fertilized. The eggs hatch in about four weeks. Male sculpins both guard the nest and care for the young. Slimy Sculpin feed pri-



Slimy Sculpin: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

marily on bottom-dwelling invertebrates, particularly aquatic insect larvae and nymphs. Small crustaceans, fishes, and aquatic vegetation are consumed in lesser amounts.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Slimy Sculpin are common and widely distributed in suitable habitats west of the Connecticut River. East of the Connecticut River, there are small, geographically isolated populations in the Millers, Chicopee, and Nashua river basins. In 1861, specimens were taken from the lower Merrimack near Lawrence, but this population has apparently been extirpated since they were last reported from the entire area in 1953. The continued presence of Slimy Sculpin in eastern Massachusetts depends on the protection of habitat adjoining hill-streams. In addition, changes in water quality, probably due to acid rain, have impacted a number of Slimy Sculpin populations in tributaries to the Quabbin Reservoir in north-central Massachusetts.

NOTES. The sculpins' reputation as being detrimental to trout is unfounded. While sculpins are closely associated with trout in Massachusetts, they have no documented negative effect on the survival of trout populations. In small, high-gradient streams, they are often the only fish species found in association with Brook Trout. Reports of Mottled Sculpin, *Cottus bairdi,* from Massachusetts may stem from the fact that Massachusetts Slimy Sculpin often have four pelvic rays on one side or the other but are true *C. cognatus* in other characteristics.

REFERENCES. Godkin et al. 1982 (identification); Halliwell 1989 (decline); Jenkins and Burkhead 1993 (identification, review); Koster 1937 (life history); Lyons 1990 (distribution); Mousseau et al. 1988 (reproduction); Schlotterbeck 1954 (Merrimack); Symons et al. 1976, Coon 1987 (temperature); Van Vliet 1964 (ecology).

Striped Bass Family

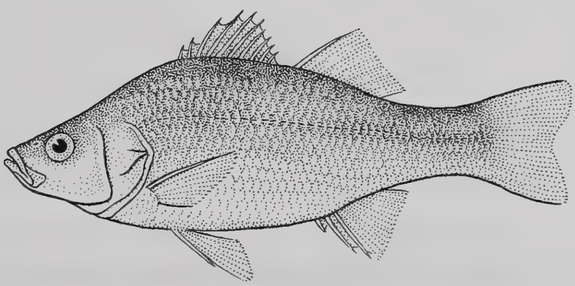
Moronidae

The striped bass family is a somewhat primitive group of spiny-finned fishes. The classification of these sea basslike fishes has changed in recent years, and the striped basses have been removed from the Percichthyidae and placed in a separate family, Moronidae. This small family consists of four North American species and two from the Mediterranean area of Europe and Africa. Some are anadromous and migrate long distances. They have been considered to be closely related to the true sea bass family (Serranidae), but recent research suggests that they might be more closely related to the snooks (Centropomidae). Unlike the sea basses, members of this family usually have two opercular spines. The striped bass family also has two dorsal fins placed fairly close together and three anal spines.

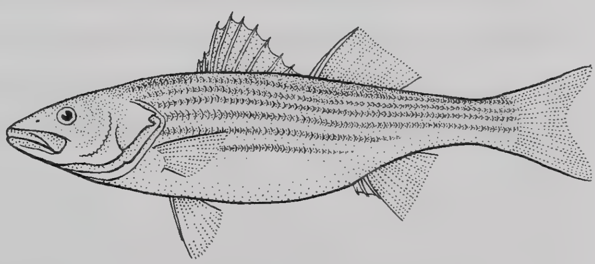
REFERENCES. Johnson 1984 (relationships, development); Fritzsche and Johnson 1980, Waldman 1986 (development and identification).

Key to Massachusetts Striped Basses

1a. Dorsal fins slightly joined at base by membrane; second anal fin spine almost equal in length to third; 1 opercular spine; no dark horizontal stripes on body. White Perch, *Morone americana*, page 236, Plate 56.



1b. Dorsal fins entirely separate; anal spines graded in length with the second intermediate between first and third; 2 opercular spines; 7 or 8 dark horizontal stripes on body. Striped Bass, *Morone saxatilis*, page 238.

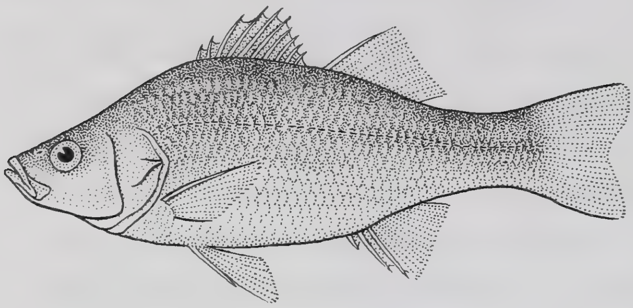


White Perch

Native

Morone americana (Gmelin 1789)

PLATE 56

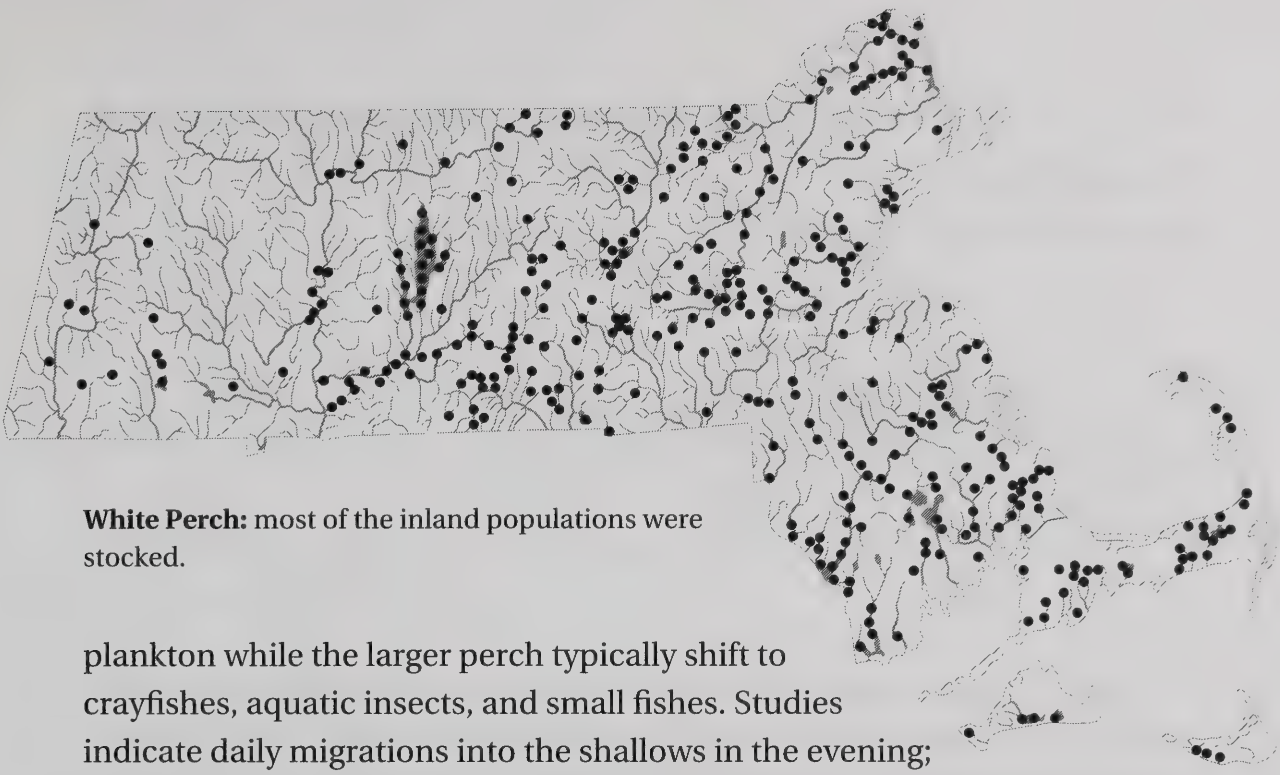


IDENTIFICATION. White Perch are relatively deep-bodied, spiny fishes with two dorsal fins that are just slightly connected, and three anal spines. Young White Perch and Striped Bass might be confused, but White Perch have a single opercular spine and the second anal spine is almost as long as the third. Adult White Perch lack the stripes found on Striped Bass.

SELECTED COUNTS. D IX,I,11–12; A III,9–10; Scales 8–9/46–50/10–12; GR 20–23.

SIZE. White Perch average 6 to 10 inches TL and .5 to 1 pound in weight. The current Massachusetts sport fish awards record is a 3-pound, 2-ounce fish from Wachusett Reservoir in 1994.

NATURAL HISTORY. White Perch tolerate a wide range of salinity and water temperature and live in marine, estuarine, and fresh waters. Estuarine populations generally spawn on sand and gravel bars in freshwater coastal streams during April to May. Landlocked freshwater populations spawn along gravel shorelines from May to June at water temperatures of 50° to 60°F. During spawning, 10 to 50 smaller males attend a few larger females. Nests are not built, and the adhesive eggs are scattered over the bottom during one to two weeks. Parents do not take care of eggs and young. Eggs hatch in four to six days, depending on water temperature, and the young grow rapidly, reaching 1.5 to 2.5 inches TL by late summer. Their average life span is six to seven years, but they have been known to live for 17 years. White Perch tend to form schools of a few to hundreds of fish. Their prey vary with habitat and age. In freshwater, the young feed primarily on small



White Perch: most of the inland populations were stocked.

plankton while the larger perch typically shift to crayfishes, aquatic insects, and small fishes. Studies indicate daily migrations into the shallows in the evening; they return to deeper offshore waters during the daytime.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, White Perch were originally restricted to estuarine streams and coastal freshwater ponds. They were introduced to many ponds statewide and are now common to abundant. Most inland landlocked populations are the result of stocking programs that started in the early 1900s.

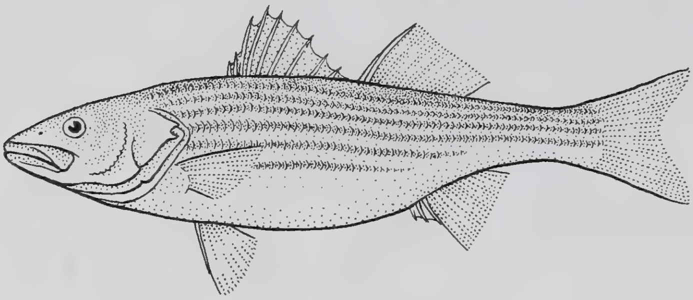
NOTES. White Perch have a strong tendency to overpopulate lakes and ponds, which results in large numbers of stunted individuals. When this happens, White Perch also compete with other species for food resources. In spite of its reputation as an excellent food and sport fish, White Perch are underused by Massachusetts anglers.

REFERENCES. Webster 1943, Alsop and Forney 1962 (food); Thoits 1958, Mansueti 1961, 1964a, Clayton et al. 1976, Bath and O'Connor 1982 (life history); Holsapple and Foster 1975 (reproduction); Kellogg and Gift 1983 (growth); Aziz 1992 (fishing, MA); Waldman 1986 (identification); Cardoza et al. 1993 (introductions).

Striped Bass

Native

Morone saxatilis (Walbaum 1792)

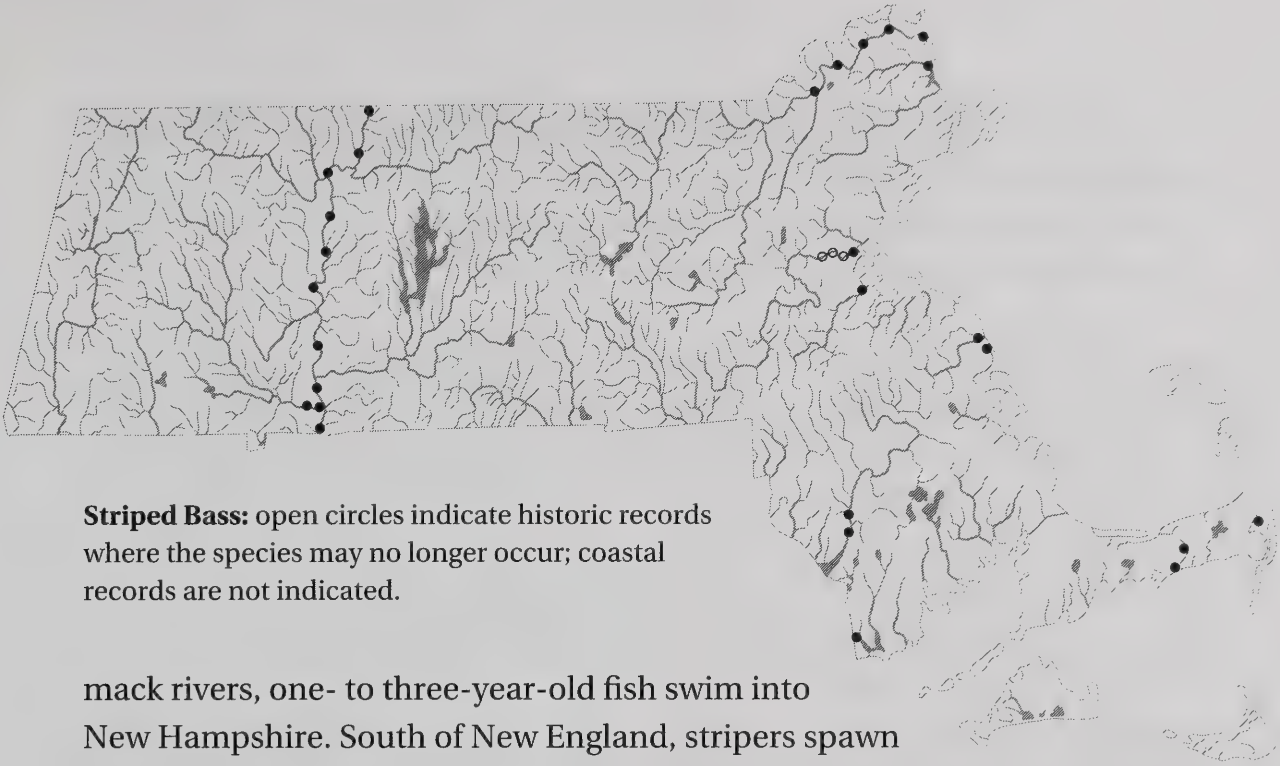


IDENTIFICATION. Striped Bass are moderately elongate as young but can become quite stout as adults. Their two dorsal fins are separated by a small space, and they have three anal spines. Young White Perch and Striped Bass might be confused, but Striped Bass have two opercular spines and their anal spines increase gradually in length. Adult Striped Bass have an olive-green to bluish back that grades to silvery sides and a white belly. As their name implies, they have seven to eight dark horizontal stripes along the body.

SELECTED COUNTS. D IX,I,11–14; A III,11; Scales 53–65; GR 25.

SIZE. Striped Bass can grow to be large fish; records of over 100 pounds have been historically noted. Today, most specimens are from 3 to 40 pounds. Three fishes, each weighing 73 pounds, hold the current Massachusetts angling record.

NATURAL HISTORY. Striped Bass move into Massachusetts waters during summer months as water temperatures reach 57° to 64°F. All of the Striped Bass found along the Massachusetts coast and in inland rivers are the products of migratory populations that spawn farther south from the Hudson to the Chesapeake. It is unknown if Striped Bass historically spawned in Massachusetts rivers, and the only indication that they might have is the mid-1600s description of large numbers running up the Merrimack with spring Alewives, and a series of young-of-the-year stripers that were collected in the Parker River estuary in 1930. Stripers often migrate hundreds of miles inland in larger rivers. In the Connecticut and Merri-



Striped Bass: open circles indicate historic records where the species may no longer occur; coastal records are not indicated.

mack rivers, one- to three-year-old fish swim into New Hampshire. South of New England, stripers spawn in the spring, and the young stay in their native rivers or estuaries until they are two years old or about 1 foot long. Males and females grow at different rates: 15-year-old males will reach an average of 42 inches, while females of the same age reach 47 inches and are much heavier. The number of eggs produced by females also varies with age and size. A 4-pound female might produce 250,000 eggs although a 50-pound fish might produce somewhere around 5,000,000. Females do not mature until they are four to six years old. As might be expected, diet varies with size: young fish feed on smaller amphipods, shrimp, and crabs; older fishes are voracious and consume many larger prey, including herrings, smelt, anchovies, eels, sea-worms, squid, and crabs. Striped Bass may live as long as 40 years.

DISTRIBUTION AND ABUNDANCE. Historically, Striped Bass were abundant and probably entered most of Massachusetts' larger rivers before the appearance of environmental changes associated with dams and pollution. Improvements to many of Massachusetts' fishways during the last decade currently allow nonreproducing stripers to migrate the length of the Connecticut and Merrimack rivers into New Hampshire (Figure 3). Juvenile stripers are also found in the Taunton River. Striped Bass typically undergo natural population fluctuations that have been documented since before the turn of the 20th century. The changes in abundance have now been linked to peak years of successful reproduction followed by less successful years. Recently, these natural fluctuations have been compounded by human-induced changes that affect water quality and thus reproductive

and larval success. In fact, the species declined to such low levels that some people speculated that it might become extinct during the 1970s. Strict regulations put in place at that time allowed the species to rebound, and by the late 1990s it had greatly increased in abundance.

NOTES. Historical reports from the mid-1600s note that a single man with a codline baited with lobster might catch from 12 to 20 bass in three hours in the Boston area. Likewise, two to three thousand fish could be taken in one tide with blocknets across a creek. Bass were considered so important that laws were enacted to prevent them from being used as fertilizer 20 years after the Pilgrims landed. In 1670, the colonists restricted all income from bass fished at Cape Cod to be used to establish a town school.

REFERENCES. Bigelow and Schroeder 1953, Raney 1952, Clayton et al. 1978, Smith and Wells 1977 (abundance, life history); Frisbie 1967 (growth, MA); Setzler et al. 1980 (synopsis); Markle and Grant 1970 (diet); Radin 1997 (recovery).

Sunfish and Black Bass Family

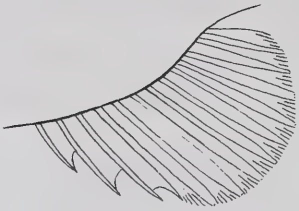
Centrarchidae

The centrarchid family is endemic to North America and has eight genera and 29 species, including such important warmwater game fishes as the black bass (Largemouth Bass and Smallmouth Bass), crappies, and sunfishes. Due in part to their general hardiness and much-sought-after game fish qualities, several species have been extensively introduced and now have almost worldwide distributions. Within the United States, centrarchids have been transplanted to such an extent that their original ranges are sometimes in question. Centrarchids have united spiny and soft dorsal fins and lack opercular spines. Large opercular flaps are often present, particularly in male sunfishes, and the mouth is terminal with numerous, small, conical teeth. They tend to be territorial, especially during their midspring to midsummer breeding periods. Males build and defend nests and attract females with well-defined courtship displays. The nest may consist of a shallow pit in gravel or sand or occasionally simply a cleaned area in rubble or vegetation. These nests, especially in certain *Lepomis* species, are occasionally tightly clustered in "breeding colonies." Males and females of some species mate with numerous partners, and a single nest may contain the eggs of several females. After spawning, the males take care of the nest and young until several weeks after hatching. In North America, members of this family are some of the most economically important and sought-after game fishes.

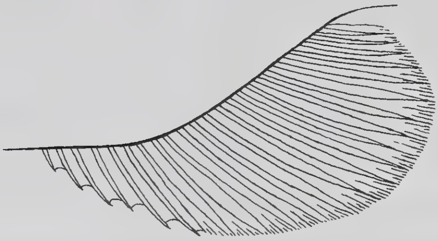
REFERENCES. Avise et al. 1977, Branson and Moore 1962, Mabee 1988 (systematics); Breder 1936 (reproductive biology); Hubbs 1955, Childers 1967 (hybrids); Etnier 1971 (diet and hybrids); Gross 1982 (reproductive biology); Werner and Mittelback 1981 (behavioral ecology).

Key to Massachusetts Sunfishes, Crappies, and Black Basses

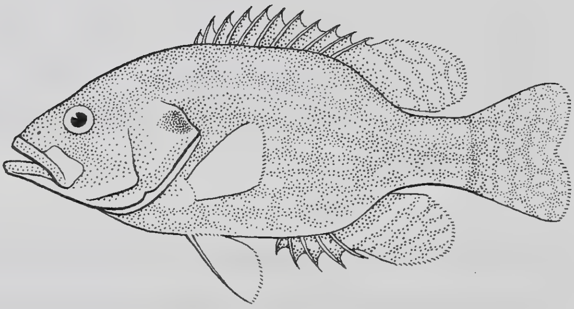
1a. Anal fin with 3 spines (rarely 2 or 4). Go to 4.



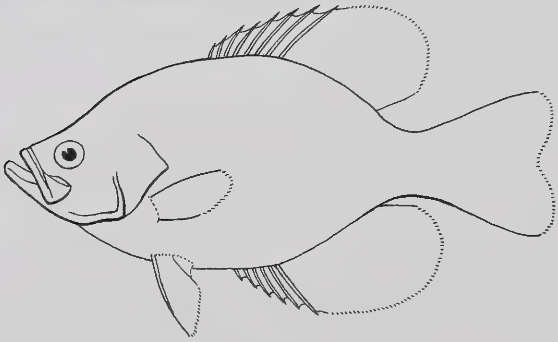
1b. Anal fin with 5 or more spines. Go to 2.



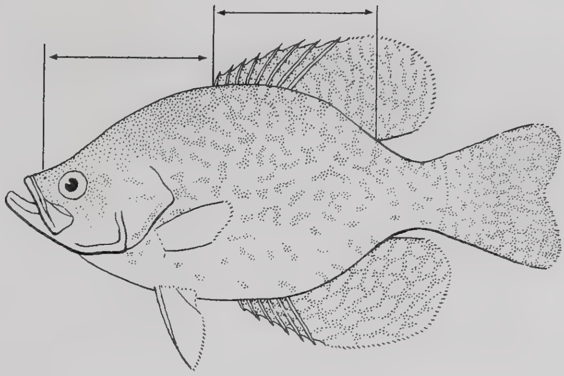
2a. Dorsal fin spines 11 to 13; dorsal fin much longer than anal fin. Rock Bass, *Ambloplites rupestris,* page 246, Plate 60.



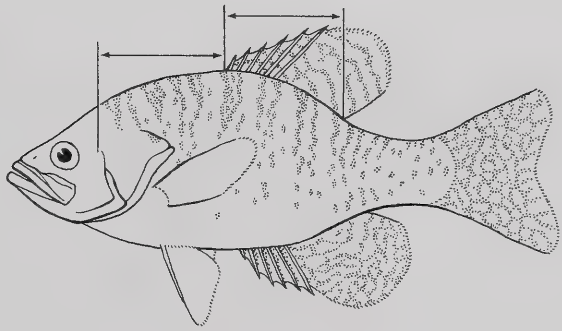
2b. Dorsal fin spines 8 or fewer; dorsal and anal fins of about equal length. Crappies. Go to 3.



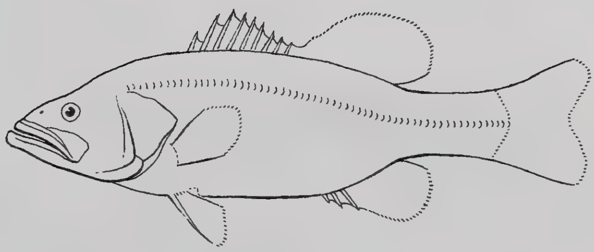
3a. Length of dorsal fin base equal to or greater than distance from eye to origin of dorsal fin; dorsal spines 7 to 8 (sometimes 6); body with mottled color pattern. Black Crappie, *Pomoxis nigromaculatus*, page 264, Plate 58.



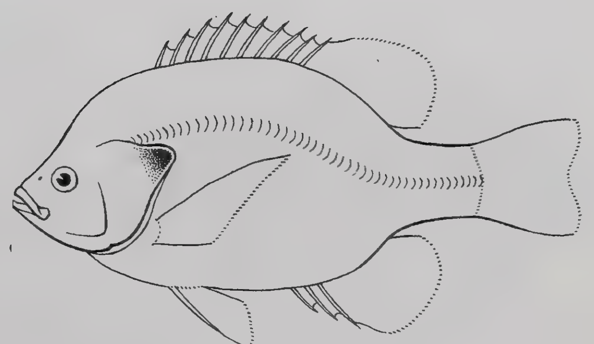
3b. Length of dorsal fin base less than distance from eye to the origin of the dorsal fin; dorsal spines 5 to 6 (sometimes 7); body with dark vertical bars. White Crappie, *Pomoxis annularis*, page 262.



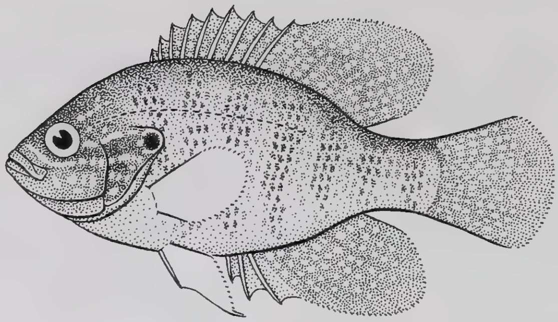
4a. Fifty-eight or more scales in lateral series; body elongate. Black Basses. Go to 9.



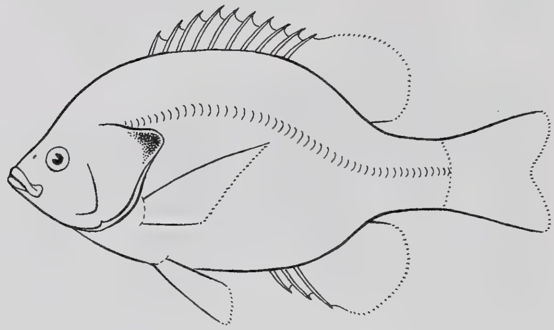
4b. Fifty-three or fewer scales in lateral series; body deep and laterally compressed. Sunfishes. Go to 5.



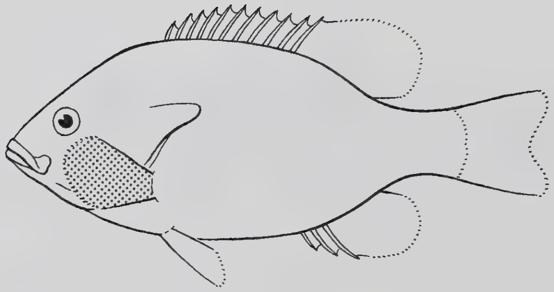
5a. Tail fin rounded. Banded Sunfish, *Enneacanthus obesus*, page 248, Plate 57.



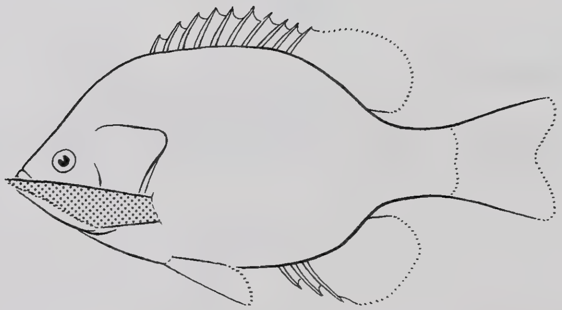
5b. Tail fin at least slightly forked. Go to 6.



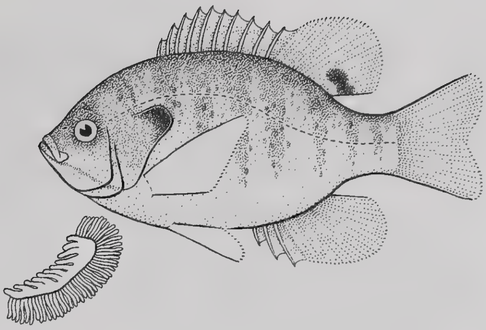
6a. Pectoral fins short, rounded, and barely reaching eye if fin is folded forward. Go to 8.



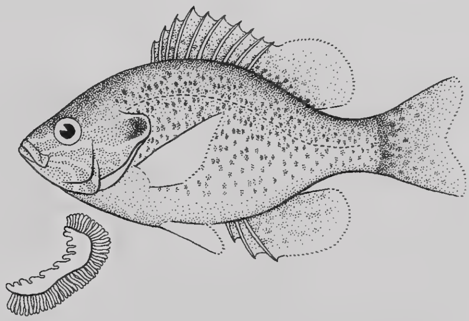
6b. Pectoral fins long, pointed, and reaching beyond middle of eye if fin is folded forward. Go to 7.



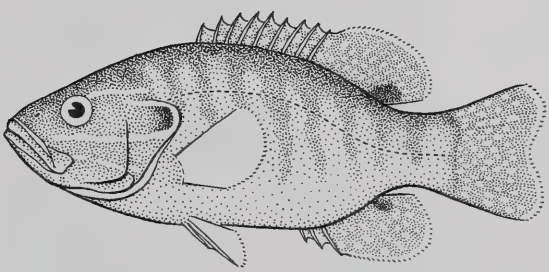
7a. Soft dorsal fin with distinct dark spot near base of last few rays; gill rakers on first arch more than twice as long as wide; opercular flap flexible, "squared," and without light-colored margin. Bluegill, *Lepomis macrochirus,* page 256, Plate 59.



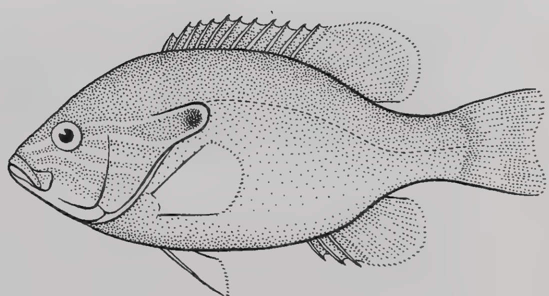
7b. Soft dorsal fin without large dark spot near base of last few rays; gill rakers on first arch not more than twice as long as wide; opercular flap stiff, rounded, and with red/orange spot on lower margin. Pumpkinseed, *Lepomis gibbosus,* page 254, Plate 62.



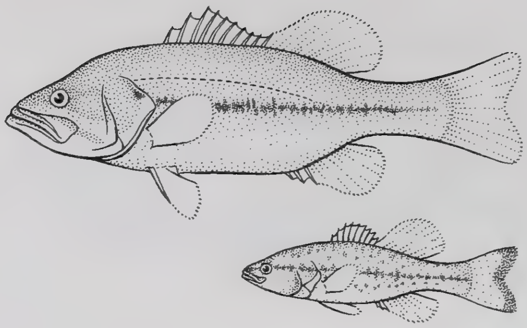
8a. Mouth large, maxilla often extending to rear margin of eye; opercular flap stiff and relatively short. Green Sunfish, *Lepomis cyanellus,* page 252.



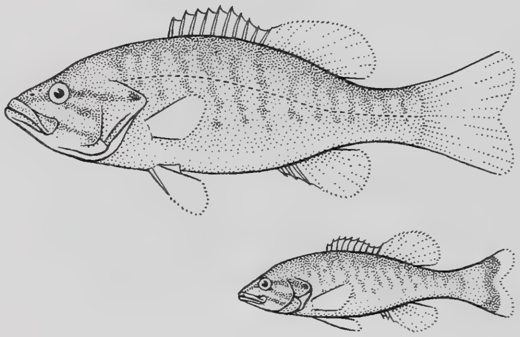
8b. Mouth small, maxilla extending, at most, to midpoint of eye; opercular flap flexible and often long (especially in large males). Redbreast Sunfish, *Lepomis auritus,* page 250, Plate 61.



9a. Soft and spiny portions of dorsal fin connected by membrane only at base; dark midlateral stripe on each side; no scales present along the base of soft dorsal fin; juveniles without tricolored tail (tail may be bicolored). Largemouth Bass, *Micropterus salmoides,* page 260, Plates 64 and 65.



9b. Soft and spiny portions of dorsal fin connected well above the body; no dark midlateral stripe; scales present along base of soft dorsal fin; juveniles with tricolored tail (base of fin orange, middle dark, outer edge white/clear). Smallmouth Bass, *Micropterus dolomieu,* page 258, Plates 63 and 65.

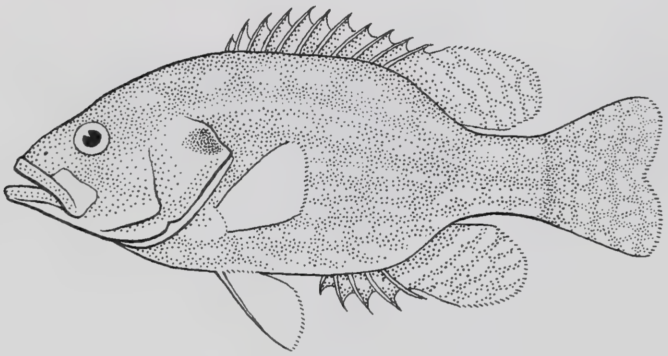


Rock Bass

Introduced

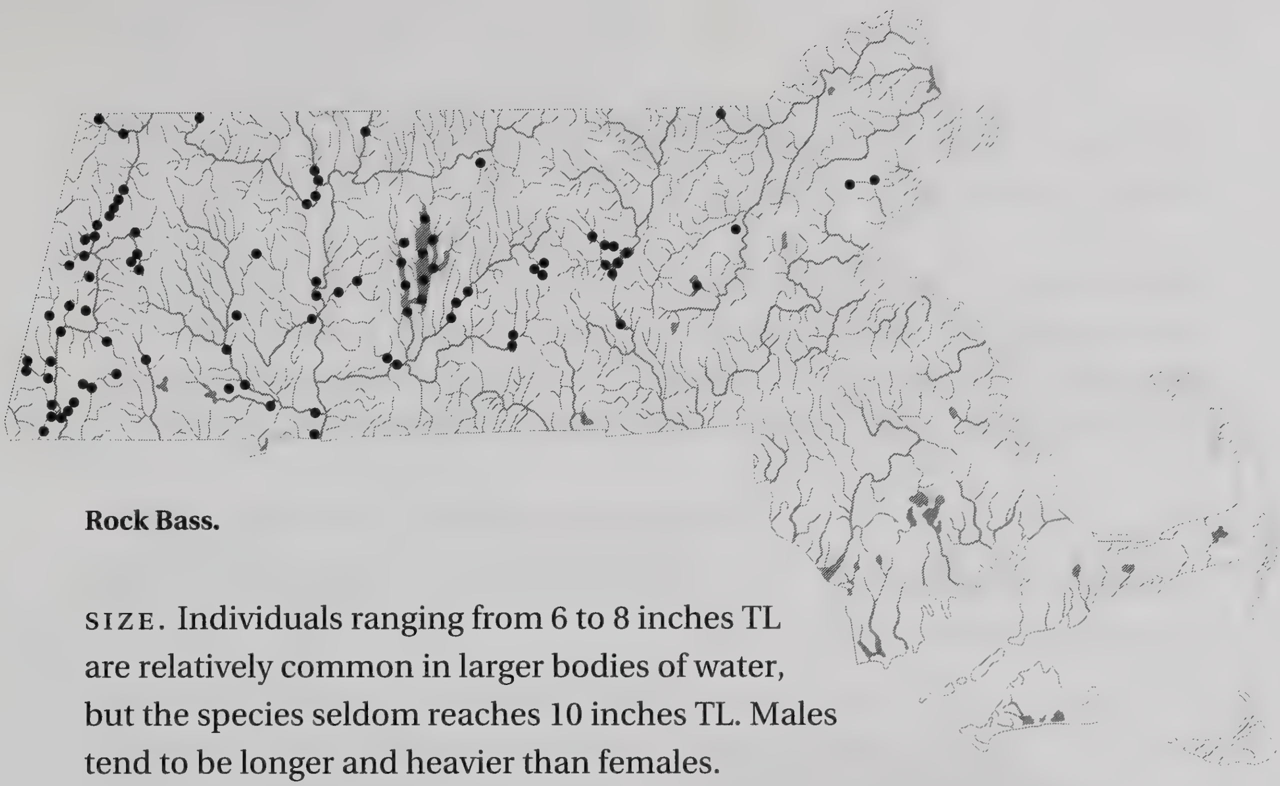
Ambloplites rupestris (Rafinesque 1817)

PLATE 60



IDENTIFICATION. Rock Bass are medium-sized centrarchids with large mouths that reach back to below the pupil, short rounded pectoral fins, 10 to 12 dorsal spines and 5 to 7 anal spines.

SELECTED COUNTS. D X–XII, 10–12; A V–VII,9–11; Scales 7/38–43/12; GR 12.



Rock Bass.

SIZE. Individuals ranging from 6 to 8 inches TL are relatively common in larger bodies of water, but the species seldom reaches 10 inches TL. Males tend to be longer and heavier than females.

NATURAL HISTORY. Rock Bass are primarily bottom-dwelling fish. They inhabit portions of large streams that have cool, clear waters with extensive cover, such as submerged stumps or large rocks. Rock Bass are also commonly found in lakes and reservoirs where the appropriate conditions of cool, clean water and ample cover are satisfied. In Massachusetts, spawning probably begins in early June and continues for several weeks. The males build nests, often close together, in shallow water in areas of silt-free gravel and rocky bottoms. Females have been found to carry 2,000 to 11,000 eggs. Rock Bass mature at age three or four. Individuals have been found to live at least eight years in Massachusetts. Rock Bass feed on a variety of prey. The young feed mostly on zooplankton and small benthic invertebrates while larger individuals switch to a diet of fishes and relatively large invertebrates, such as crayfishes and dragonfly larvae.

DISTRIBUTION AND ABUNDANCE. Rock Bass were first introduced into Massachusetts in 1934. Distribution in this state is primarily western, with the majority of records from the Hoosic and Housatonic drainages as well as the major tributaries to the Connecticut River. Rock Bass are locally common in the Farmington, Deerfield, Millers, Chicopee, and Westfield rivers, as well as in the Quabbin and Wachusett reservoirs.

NOTES. Where found, Rock Bass are an interesting game fish that put up a good fight on a light rod. However, the introduction of this competitive fish

eliminated a population of the Roanoke Bass, *Ambloplites cavifrons,* and a Brook Trout fishery in Virginia.

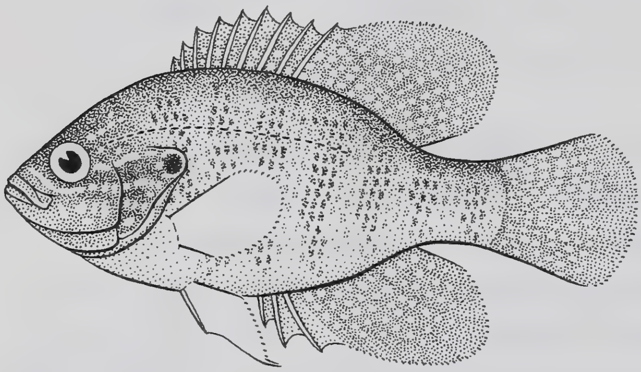
REFERENCES. Cashner and Jenkins 1982 (systematics); Gross and Nowell 1980 (reproductive biology); Keast 1977b (behavioral ecology); Keast and Webb 1966 (diet); Noltie 1988 (growth); Trautman 1981 (general); Woronecki 1966 (life history, Quabbin Reservoir); Jenkins and Burkhead 1993 (VA).

Banded Sunfish

Native

Enneacanthus obesus (Girard 1854)

PLATE 57

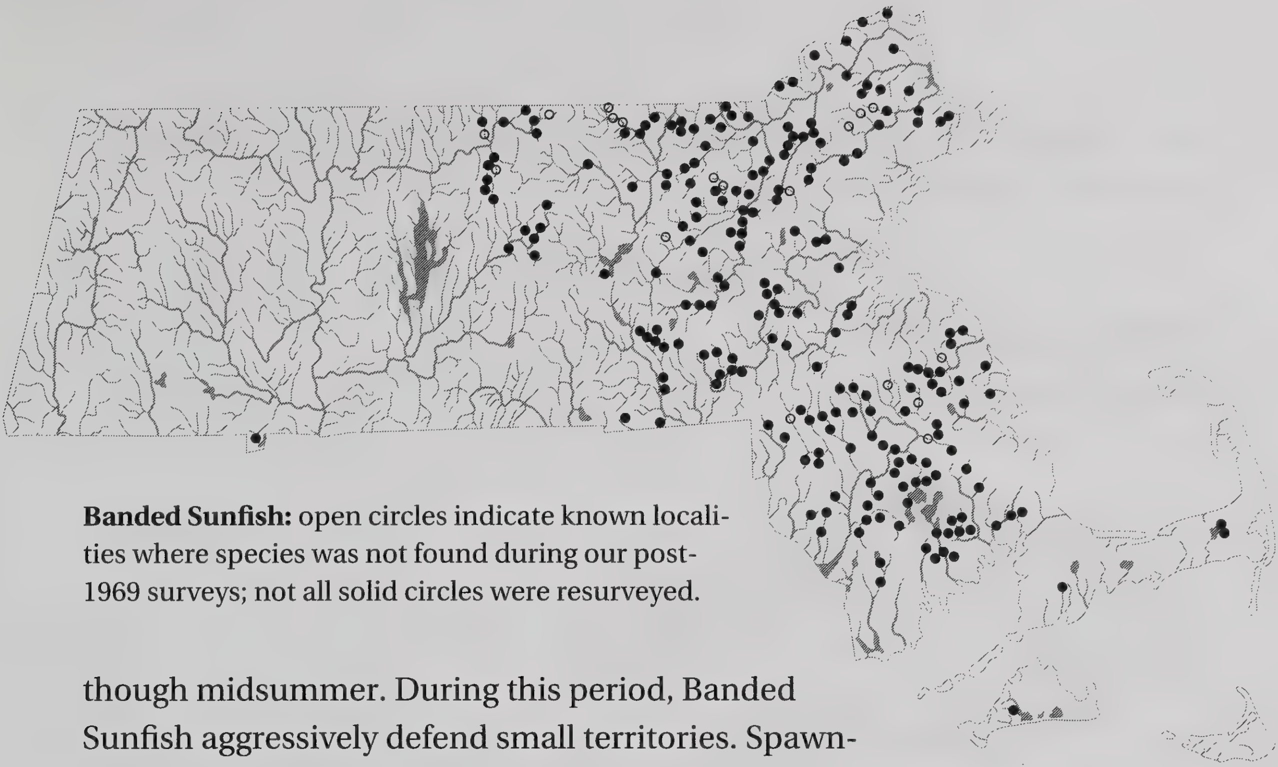


IDENTIFICATION. Banded Sunfish are small (usually less than 3 inches TL), stout-bodied fishes, and they are the only local sunfish with rounded tail fins and short-round pectoral fins. They are olive-green to brown with numerous small bronze, silver-green, and light blue spots on the body, and five to eight dark vertical bars.

SELECTED COUNTS. D VIII–IX,11–12; A III,10–11; Scales 5/30–33/10–11; GR 13–14.

SIZE. Banded Sunfish rarely exceed 2 to 3 inches TL. The largest Massachusetts specimen that we have seen measures 4.25 inches TL (80 mm SL).

NATURAL HISTORY. Banded Sunfish live in quiet backwaters, swamps, and ponds. They are frequently associated with heavy aquatic vegetation and have been observed to thrive in naturally acidic waters. They appear to have a protracted breeding season, beginning in late spring and extending



Banded Sunfish: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

though midsummer. During this period, Banded Sunfish aggressively defend small territories. Spawning occurs in small nests constructed at the base of aquatic vegetation or occasionally well above the bottom in the vegetation itself. Banded Sunfish usually live three to four years, although five-year-old specimens have been recorded. They feed on a wide variety of small aquatic invertebrates, including cladocerans, copepods, dipterans, and amphipods. The relative size and seasonal abundance of prey greatly influence their diet. In the laboratory, they readily feed on small fishes and crayfishes.

DISTRIBUTION AND ABUNDANCE. Banded Sunfish inhabit the Atlantic coast from New Hampshire to Alabama. The species is widespread in most of eastern Massachusetts but known only from a few sites on Cape Cod. We found it at two locations on Martha's Vineyard in 1988, but not on Nantucket. In the inland portion of the state, Banded Sunfish have been seen only in the upper Chicopee Drainage (Burnshirt and Ware rivers), Nashua River, and the upper Millers River drainages. These Chicopee and Millers populations are most likely the result of stream capture with the Merrimack Basin. This species is still common in the proper habitat but has declined with urban sprawl when small, swampy wetlands were drained.

NOTES. The Banded Sunfish was first described from specimens collected at Hingham and Holliston, Massachusetts, by C. Girard in 1854.

REFERENCES. Breder and Redmond 1929 (reproduction); Graham and Felly 1985 (hybrids); Gonzales and Dunson 1989 (pH tolerance); Graham

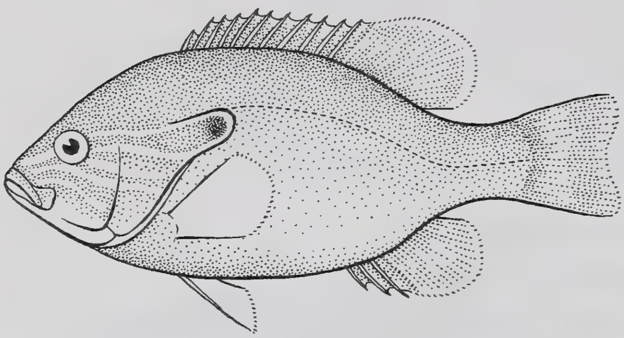
and Hastings 1984 (habitat); Harrington 1956 (reproduction); Lima 1986 (ecology); Sweeny 1972 (systematics).

Redbreast Sunfish

Native

Lepomis auritus (Linnaeus 1758)

PLATE 61

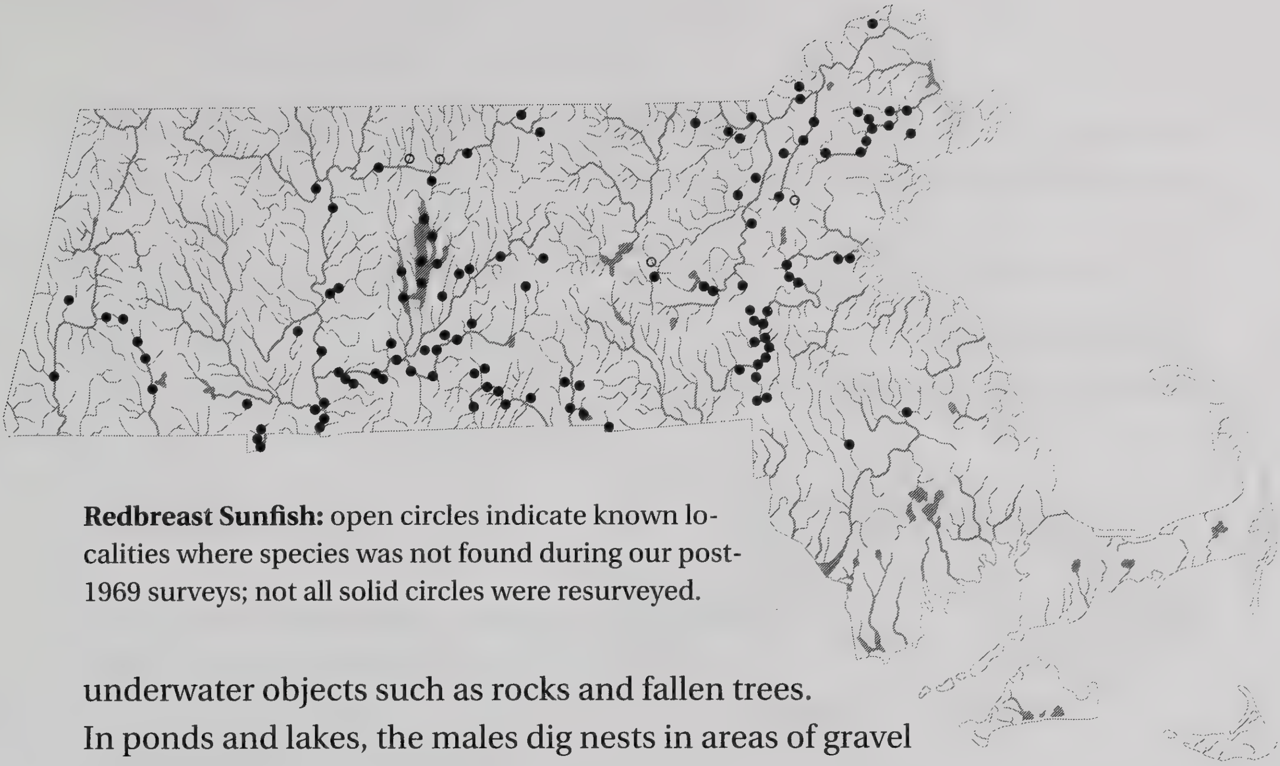


IDENTIFICATION. Redbreast Sunfish have united dorsal fins, three anal fin spines, short and rounded pectoral fins (not reaching to the front of the eye when folded forward) (see key Figure 6a), less than 13 short thick gill rakers, and a relatively large mouth that reaches well past the anterior edge of the eye. Adults (particularly males) have elongate, dark-blue or black opercular flaps that lack a red or orange posterior margin. Redbreast Sunfish are much more elongate and less deep-bodied than most other local sunfishes. The body is olive-green to yellow-tan, the belly is red to yellow, and several light blue, irregular horizontal stripes cross the cheeks and gill covers. The fins, particularly the tail and pelvic fins, are often red or orange.

SELECTED COUNTS. D X,10–12; A III,9–10; Scales 7/42–46/14; GR 10–13.

SIZE. Individuals 4 to 8 inches TL have been commonly recorded. The largest Massachusetts specimen that we have measured is about 6 inches TL (126 mm SL).

NATURAL HISTORY. Redbreast Sunfish generally live in ponds, lakes, or the slow-moving sections of streams and rivers. They are often found in clean water with rocky bottoms and seem to avoid heavily vegetated areas. The spawning season is from late spring through midsummer. In rivers and streams, Redbreast Sunfish usually make nests in sheltered areas, near



Redbreast Sunfish: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

underwater objects such as rocks and fallen trees. In ponds and lakes, the males dig nests in areas of gravel and sand bottoms. These nests are often tightly grouped. Medium-sized females have been recorded to contain 500 to 6,500 eggs. Diet consists of a wide variety of larval and adult aquatic insects, including mayflies, caddisflies, midges, flies, mosquitoes, beetles, and dragonflies. Scuds, aquatic sowbugs, mollusks, and small fishes are occasionally eaten.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Redbreast Sunfish have a scattered distribution. D.H. Storer (1839) mentioned that this species was common, but currently we have found it to be relatively common only in a few locations: the upper Charles and Sudbury rivers, the Quabbin Reservoir, and the main stems of the Connecticut and Merrimack rivers. In other Massachusetts drainages, this species is not common, and it is rare or absent in the southeastern portion of the state and most hillstream areas. It is probable that this species has declined since the mid-1800s due to changes in water quality or behavioral interactions with introduced species, especially the Bluegill.

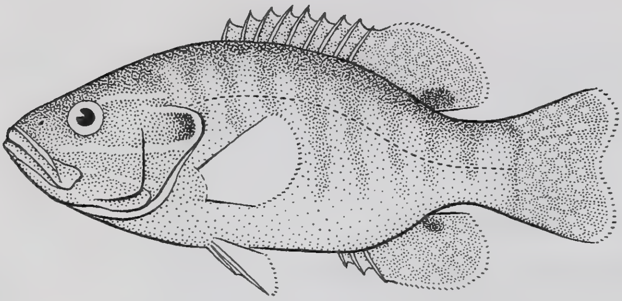
NOTES. The Longear Sunfish, *Lepomis megalotis,* has often been reported from Massachusetts, but we have never seen a specimen. These reports are probably the result of misidentifications of adult male Redbreast Sunfish or incorrect use of the common name. In early references, Redbreast Sunfishes were occasionally referred to as Longear Sunfish (Kendall 1908). The Redbreast Sunfish is known to hybridize with Pumpkinseeds, Green Sunfish, Bluegills, and Warmouths.

REFERENCES. Bass and Hitt 1975 (ecology); Breder and Nigrelli 1935 (social behavior); Davis 1972 (reproduction).

Green Sunfish

Introduced

Lepomis cyanellus Rafinesque 1819

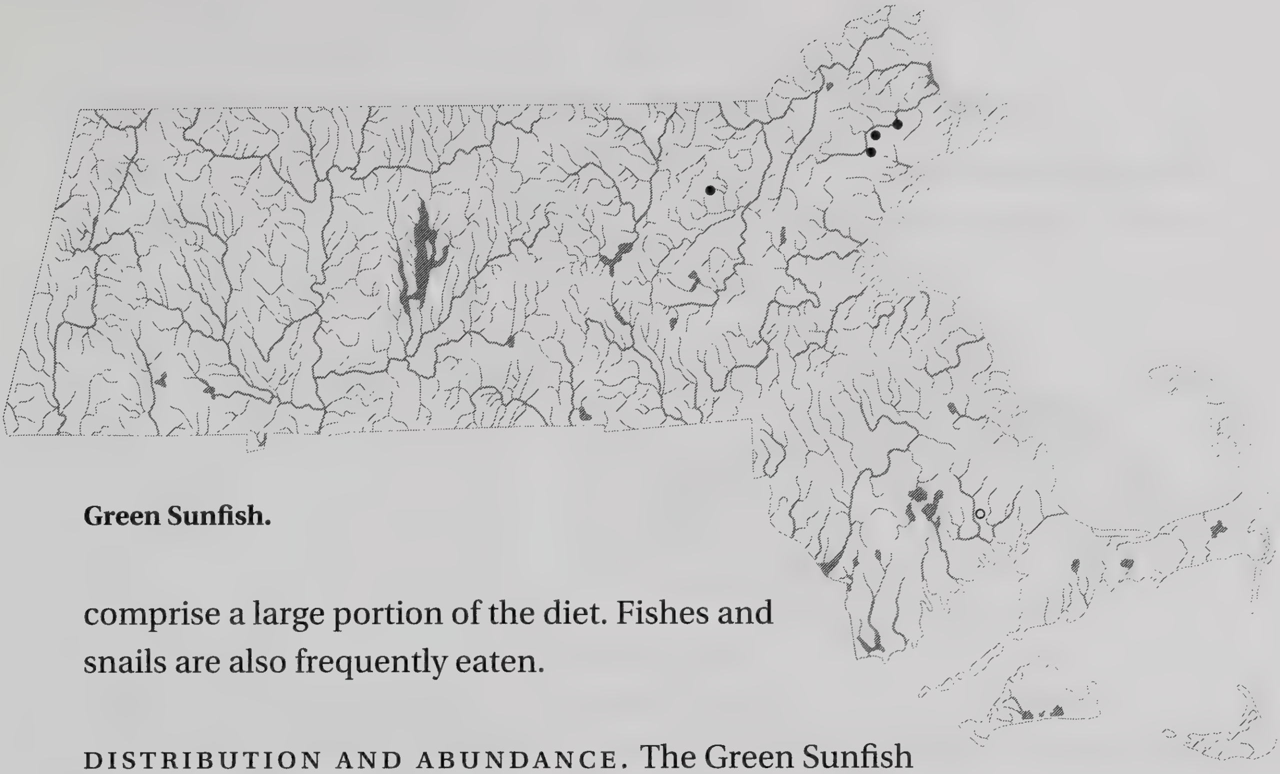


IDENTIFICATION. Green Sunfish have united dorsal fins, three anal fin spines, short and rounded pectoral fins not reaching past the posterior margin of the eye if folded forward (see key Figure 6a), and a large mouth that reaches well past the anterior margin of the eye or even past the posterior margin in large adults. The opercular flap is dark with a distinct light-colored margin, and is rigid all the way to its posterior edge. The dorsal, anal, and caudal fins have a yellow-cream margin, and there are dark blotches at the base of the soft dorsal fin and the anal fin. A series of blue-green spots and wavy lines spread from the eye to the gill cover.

SELECTED COUNTS. D X,10–12; A III, 9–10; Scales 7/45–53/15; GR 19–20.

SIZE. Green Sunfish are generally small- to medium-sized fishes that typically reach 4 to 6 inches TL.

NATURAL HISTORY. In other areas, Green Sunfish tolerate a wide range of water conditions ranging from cool, clear hill streams and brooks to warm, turbid lowland backwaters. They appear to do best, however, in small, slow-moving streams with large amounts of aquatic vegetation or other cover. In Massachusetts, the breeding season is probably from late spring to midsummer. As in other sunfishes, the males build small nests in shallow water, often closely grouped. Green Sunfish feed on a variety of aquatic invertebrates. Large benthic prey, such as larval dragonflies, usually



Green Sunfish.

comprise a large portion of the diet. Fishes and snails are also frequently eaten.

DISTRIBUTION AND ABUNDANCE. The Green Sunfish is not native to Massachusetts. The exact date of its first introduction into Massachusetts is unknown, but the species may have been accidentally introduced with shipments of Bluegills. Green Sunfish have a limited range in this state. Previously, they were common only in Nagog Pond, Acton, but 1998 MDFW surveys by T. Richards show that the species is common at several sites in the Ipswich Drainage. Photographic evidence of a single specimen documents this species in the Buzzards Bay Drainage. Unverified reports suggest that this species may be also found in the Taunton, Blackstone, and Quinebaug drainages.

NOTES. Green Sunfishes are known to hybridize with Bluegills and Pumpkinseeds, and with Longear, *Lepomis megalotis,* Redear, *Lepomis microlophus,* and Orangespotted sunfishes, *Lepomis humilis.*

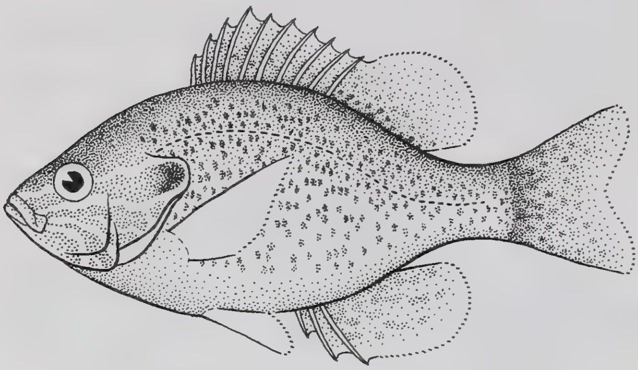
REFERENCES. Hunter and Hasler 1965 (reproduction and associations); McKechnie and Tharratt 1966 (review); Sadzikowski and Wallace 1976 (diet).

Pumpkinseed

Native

Lepomis gibbosus (Linnaeus 1758)

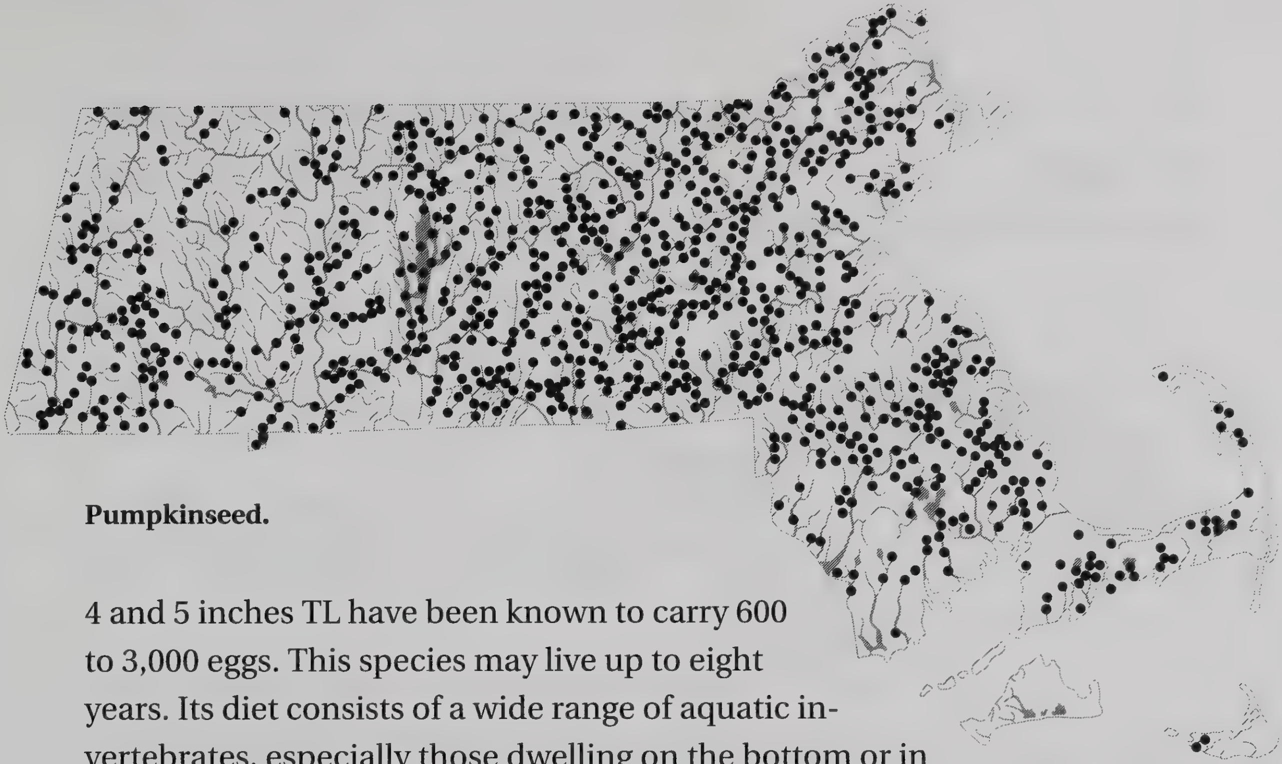
PLATE 62



IDENTIFICATION. Pumpkinseeds have three anal fin spines, a slightly forked tail, united dorsal fins, and fewer than 45 lateral-line scales. The long and pointed pectoral fins (when folded forward they reach the front of the eye) (see key Figure 6b) distinguish Pumpkinseeds from all other local sunfishes except Bluegills. Pumpkinseeds have a prominent orange-red spot and light margin on the rounded and inflexible opercular flap and lack a dark spot on the soft dorsal fin. They have fewer than 12 gill rakers that are relatively short, stout, and often crooked. However, the gill rakers of juvenile Pumpkinseeds and Bluegills appear similar when the fishes are less than 1 inch TL. The body often has 6 to 10 darker vertical bands along the body and many pale yellow, orange, golden, and olive spots on the sides of the body and head. A series of wavy, horizontal, blue bars extends from the side of the head onto the lower sides of the body. Male coloration becomes intense during breeding.

SELECTED COUNTS. D X,11–12; A III,9–10; Scales 6/38–44/13; GR 11–15.

NATURAL HISTORY. Pumpkinseeds are generally associated with areas of aquatic vegetation in lakes, ponds, marshes, and slow-moving portions of streams. Spawning is temperature dependent and usually begins in late spring and often lasts through midsummer. Males dig small depressions in shallow water, usually in open areas with sand or gravel bottoms, and defend territories that are often only a few times the size of the actual nest. Nests have been known to contain 1,500 to 14,000 fry, and females between



Pumpkinseed.

4 and 5 inches TL have been known to carry 600 to 3,000 eggs. This species may live up to eight years. Its diet consists of a wide range of aquatic invertebrates, especially those dwelling on the bottom or in vegetation. In some populations, large juvenile and adult Pumpkinseeds feed almost exclusively on snails by using their molar-like pharyngeal teeth.

SIZE. Individuals 4 to 5 inches TL are common, and occasionally specimens up to 10 inches TL are encountered.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Pumpkinseeds are common and live in virtually all parts of the state where quiet, vegetation-filled waters are present. They are found on Nantucket but not on Martha's Vineyard.

NOTES. Pumpkinseeds and Bluegills are two of the most common fishes in Massachusetts and are probably the first species caught by most beginning anglers. Pumpkinseeds are known to hybridize with Bluegills and Warmouths, *Lepomis galosus,* and with Green, Redbreast, Orangespotted, *Lepomis humilis,* and Longear sunfishes.

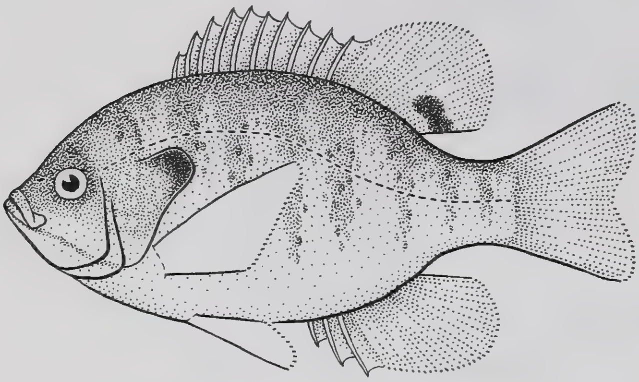
REFERENCES. Colgan and Gross 1977 (behavior); Hanson and Qadri 1984, Keast 1978, Mittelbach 1984 (diet); Miller 1963 (behavior).

Bluegill

Introduced

Lepomis macrochirus (Rafinesque 1819)

PLATE 59



IDENTIFICATION. Bluegills have three anal fin spines, a slightly forked tail, united dorsal fins, and fewer than 46 lateral-line scales. The long and pointed pectoral fins (when folded forward they reach the front of the eye (see key Figure 6b) distinguish Bluegills from all other local sunfishes except Pumpkinseeds. Bluegills have a prominent dark spot on the soft dorsal fin and a relatively long, dark, and flexible opercular flap. The opercular flap is dark blue to black to its margin. Bluegills have more than 17 relatively long, thin, and straight gill rakers. Overall color ranges from olive-green to a dusky, yellow-brown and bronze, with breeding males becoming slate blue on the head. The breast ranges from a light yellow-cream to a bright orange-red, to mahogany in breeding males.

SELECTED COUNTS. D X,10–12; A III,10–12; Scales 7/39–46/14; GR 18–20.

SIZE. Individuals 5 to 7 inches TL are frequently encountered, and large specimens up to 12 inches TL are not uncommon in some populations. A large Bluegill, weighing 2 lbs. 1 oz., caught at South Athol Pond in 1982, is the current angling record for a sunfish in Massachusetts.

NATURAL HISTORY. Bluegills typically live in warm, slow-moving portions of rivers and streams, ponds, lakes, and marshes. They have been extensively transplanted and may be found in almost every aquatic habitat in the state. The young usually spend much of the time inshore, often in and near aquatic vegetation. The adults spend much of the time in open water, well up in the

Bluegill: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

water column or loosely associated with large objects such as fallen trees, docks, and areas of aquatic vegetation. Bluegills start spawning in Massachusetts in mid-May and continue through midsummer, usually having several peak breeding periods during this season. The males build nests in shallow water or simply take over nests constructed by other species. These nests are often grouped closely together, forming loose breeding colonies. Larger females may carry over 40,000 eggs. Bluegills normally live about 5 years, but there are records of 11-year-old fishes. The young feed primarily on small benthic invertebrates and zooplankton. Adults feed on a wide variety of food sources, including zooplankton, small fishes, benthic invertebrates, and terrestrial insects from the water's surface. Aquatic vegetation is commonly ingested but is probably eaten only by accident when Bluegills are feeding on prey associated with the vegetation.

DISTRIBUTION AND ABUNDANCE. Bluegills are not native to Massachusetts. They were first introduced in 1917 and are now found in virtually all areas of the state, including Martha's Vineyard. The Bluegill is one of the most abundant fishes in the state's warmwater habitats.

NOTES. Bluegills have been known to hybridize with Green and Redbreast sunfishes and with Largemouth Bass. In many Massachusetts localities, Bluegills have rapidly overpopulated the area, with the result that most individuals are stunted.

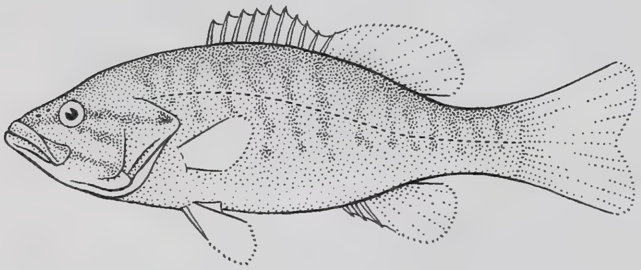
REFERENCES. Avila 1976 (reproductive biology); Dominey 1981 (reproductive ecology); Gerking 1962 (trophic biology); Keast 1977b (diet); Mayhew 1956 (reproduction); Maciolek 1984 (hybrids).

Smallmouth Bass

Introduced

Micropterus dolomieu Lacepède 1802

PLATES 63, 65

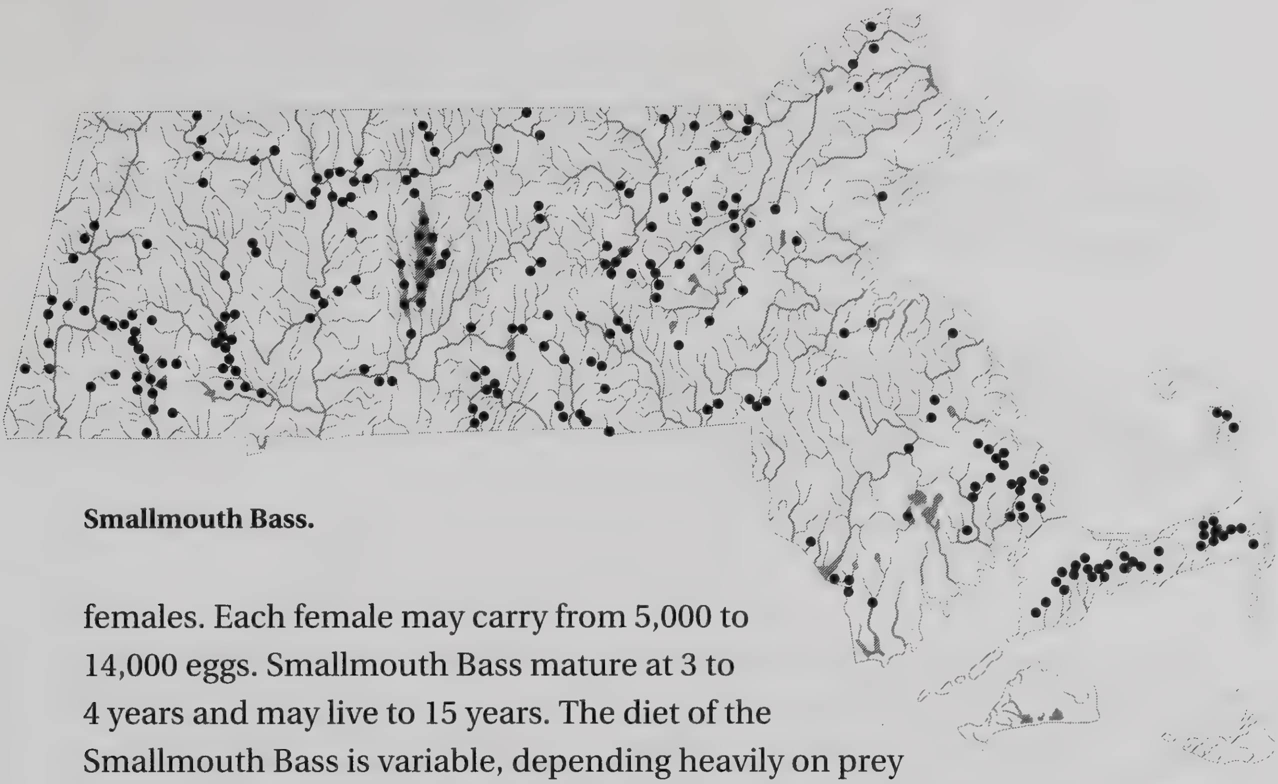


IDENTIFICATION. Smallmouth Bass are similar to Largemouth Bass. In Smallmouth Bass, the two dorsal fins are only partially separated by a notch and numerous small scales extend onto the base of the anal and dorsal fins. The posterior end of the upper jaw of the Smallmouth Bass reaches only mideye, even in the largest individuals. Adults have a series of 8 to 12 dark, irregular, vertical bars along the sides of the body, and three dark stripes radiate from the eye across the cheeks and gill covers. The tails of young Smallmouth Bass are distinctly tricolored, and they lack a prominent mid-lateral body stripe (see Plate 65).

SELECTED COUNTS. D X,13–15; A III, 10–12; Scales 13/70–78/20; GR 8–11.

SIZE. Smallmouth Bass generally range from 8 to 13 inches, with larger individuals less common. The current Massachusetts state record is 8.1 pounds and was taken from Wachusett Reservoir in 1991.

NATURAL HISTORY. Smallmouth Bass prefer clear, cool lakes and larger streams that have abundant shelter in the form of rocky areas. They generally live in cooler and cleaner waters than the Largemouth Bass. Spawning occurs in late spring and early summer. Males construct large, rock-lined nests, up to 2 to 3 feet in diameter, often near a large underwater object such as a boulder or fallen tree. The male courts and spawns with several



Smallmouth Bass.

females. Each female may carry from 5,000 to 14,000 eggs. Smallmouth Bass mature at 3 to 4 years and may live to 15 years. The diet of the Smallmouth Bass is variable, depending heavily on prey availability. In general, small individuals feed on a variety of aquatic invertebrates, primarily zooplankton, and occasionally small fish. As they get larger, Smallmouth Bass have a diet that includes more crayfishes and fishes, and, in some populations, Smallmouth Bass eat crayfishes almost exclusively.

DISTRIBUTION AND ABUNDANCE. Smallmouth Bass are not native to Massachusetts. The closest parts of their native range to Massachusetts are in areas west of the Hudson Drainage. The range of this species has been greatly extended through its introduction as a game fish. In Massachusetts, the Smallmouth Bass was first reported in 1850. Since the middle of this century, these bass were stocked in many of the state's reservoirs, lakes, and streams and can be considered locally common. In general, they are more common in the western and southeastern portions of the state.

NOTES. Smallmouth Bass are one of the most sought-after game fishes in the United States and are popular in Massachusetts. They are known to hybridize with Spotted Bass, *Micropterus punctulatus,* and rarely with Largemouth Bass.

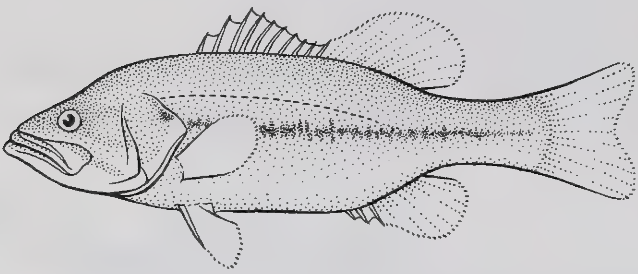
REFERENCES. Hubbs and Bailey 1938, Jenkins and Burkhead 1993 (general); MacLean et al. 1981 (age-class and temperature); Mirick 1988 (MA introductions, fishing).

Largemouth Bass

Introduced

Micropterus salmoides (Lacepède 1802)

PLATES 64, 65

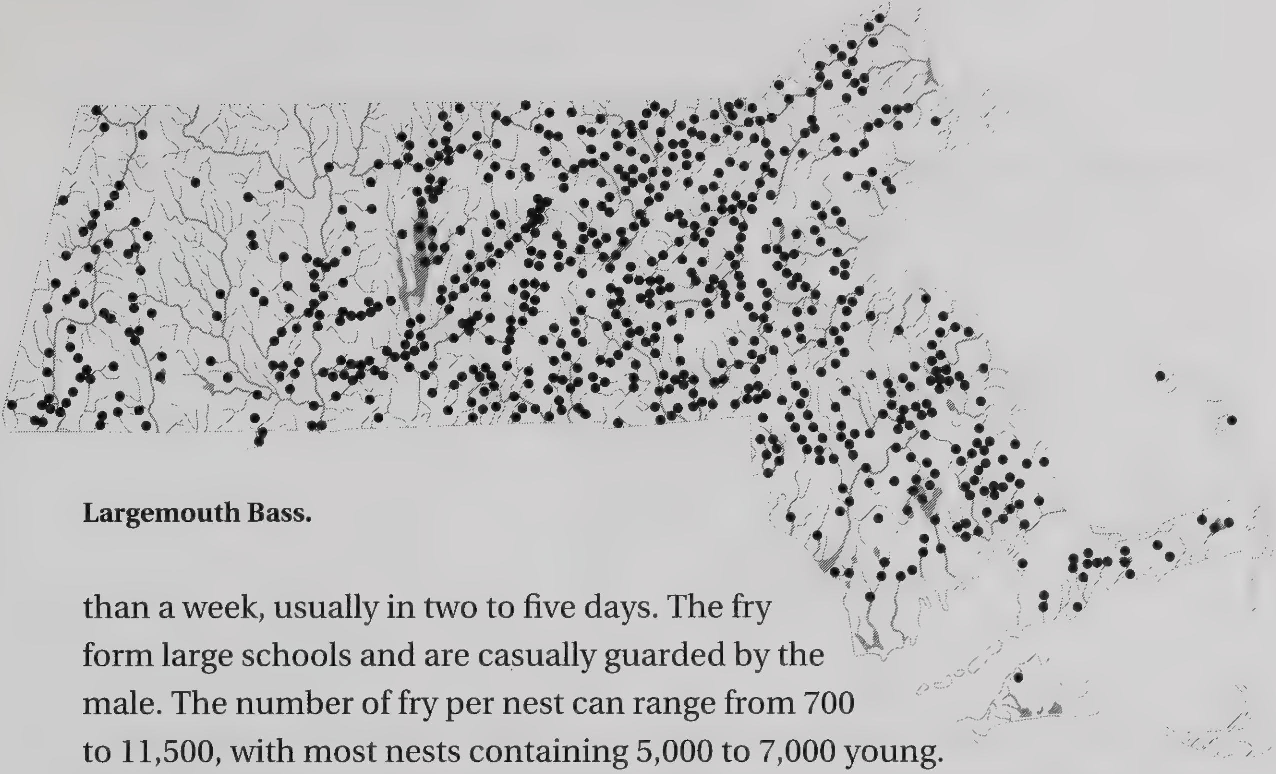


IDENTIFICATION. Largemouth Bass are similar to Smallmouth Bass. In the Largemouth Bass, the notch between the hard and soft portions fully separates the two dorsal fins, while in the Smallmouth Bass, the two fins are clearly joined at the base. Largemouths lack small scales along the base of the soft dorsal and anal fins, and in large fish the upper jaw of this species extends well past the eye. The relative length of the jaw, however, changes as the individual grows, and it is difficult to use as an identification character in small specimens. Adults and juveniles have a dark horizontal midlateral stripe, and the tails of young are bicolored, not tricolored as in the Smallmouth Bass (see Plate 65).

SELECTED COUNTS. D X–XI,12–13; A III,10–12; Scales 7/60–68/15; GR 8–10.

SIZE. Adult Largemouth Bass commonly range from 10 to 16 inches TL with larger individuals being fairly common. The current Massachusetts state record, caught at Sampson Pond in 1975, weighed 15 lbs. 8 oz.

NATURAL HISTORY. Largemouth Bass are typically found in quiet, warmwater areas and are often associated with floating and submerged vegetation. Spawning, which lasts from midspring to early summer, usually starts when water temperatures reaches 60°F. Males dig large nests, often 2 to 3 feet in diameter, in areas with sand or gravel bottoms. These nests and surrounding territories are defended by the males. Multiple spawnings in a given nest are common, because each male will court several females over the course of the reproductive season. Likewise, females will often spawn with more than one male at more than one site. Hatching occurs in less



Largemouth Bass.

than a week, usually in two to five days. The fry form large schools and are casually guarded by the male. The number of fry per nest can range from 700 to 11,500, with most nests containing 5,000 to 7,000 young. Growth can be rapid, and the young-of-the-year often reach 6 inches or more by the end of their first growing season. The young feed primarily on small aquatic invertebrates but will readily take small fishes if available. As Largemouth Bass increase in size, fish become a greater part of their diet. However, they eat, or try to eat, almost anything that swims by, including frogs, small mammals, and birds. Largemouth Bass have been known to live at least 15 years.

DISTRIBUTION AND ABUNDANCE. Largemouth Bass are native to a large area of central and southeastern North America. Largemouth Bass were first introduced into Massachusetts prior to 1862. Due to extensive public and private stocking programs, Largemouth Bass can be found in almost any body of water in the state. It is one of the most common species in many of Massachusetts' warmwater habitats.

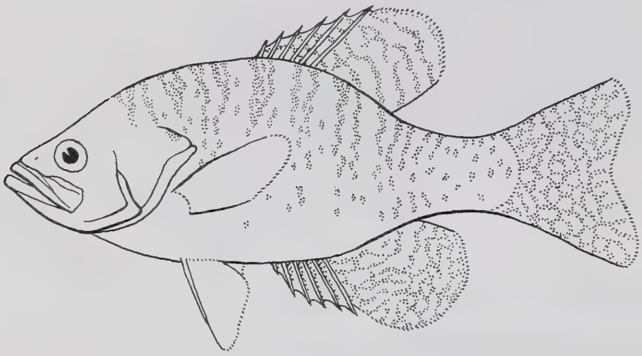
NOTES. The Largemouth Bass ranks high on the list of favorite warmwater game fish in Massachusetts. It is a voracious feeder that readily takes both natural and artificial baits. It attains a large size and is an excellent sport fish. Largemouth Bass have been documented to hybridize rarely with other members of the genus *Micropterus* and Bluegills.

REFERENCES. Emig 1966 (general biology); Hoyle and Keast 1987 (feeding behavior); Hubbs and Bailey 1940 (general summary); Maciolek 1984 (hybrids); McCaig et al. 1960 (Quabbin).

White Crappie

Introduced

Pomoxis annularis (Rafinesque 1818)



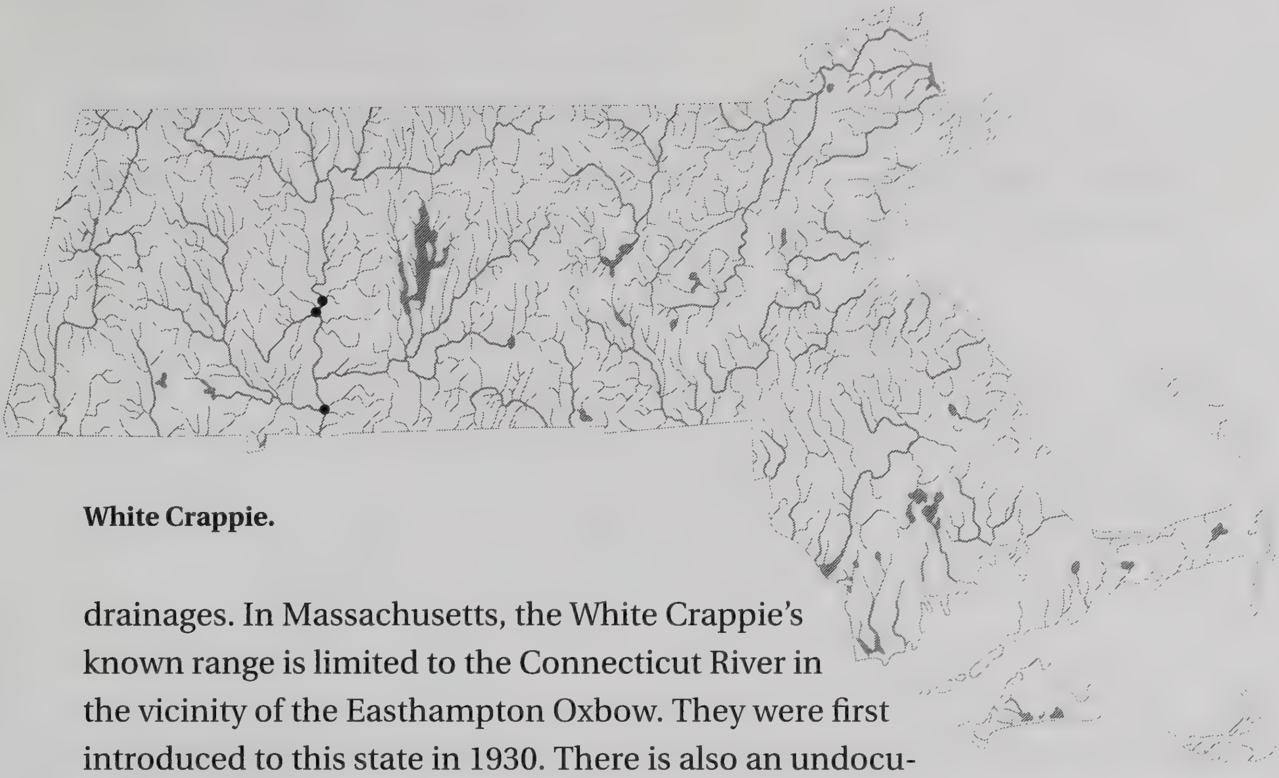
IDENTIFICATION. White Crappies have compressed, deep bodies, large mouths, sloping concave foreheads, usually five or six dorsal spines, and six or seven anal fin spines. The length of the base of the dorsal fin is usually less than three-quarters of the length from the eye and the origin of the dorsal fin (see key Figure 3b). White Crappies have a regular series of diffuse vertical bars along the sides of the body.

SELECTED COUNTS. D V–VI(VII),14–15; A VI–VII,17–18; Scales 6/34–44/13–14; GR 28–32.

SIZE. Individuals 8 to 13 inches in total length are common in many populations.

NATURAL HISTORY. White Crappies are found in lakes, ponds, marshes, and slow-moving sections of rivers and streams. They are more tolerant of siltation and turbid water than Black Crappies and are less dependent on cover. Spawning occurs from midspring to early summer. Females carry from 1,000 to 200,000 eggs, depending on their size. Young White Crappies feed primarily on zooplankton, which they catch in midwater. Larger individuals also feed on midwater organisms, including relatively small fishes and aquatic invertebrates. White Crappies are most active during the twilight hours and at night.

DISTRIBUTION AND ABUNDANCE. White Crappies are native to the Mississippi River Basin, the Great Lakes region, and the western Gulf Coast



White Crappie.

drainages. In Massachusetts, the White Crappie's known range is limited to the Connecticut River in the vicinity of the Easthampton Oxbow. They were first introduced to this state in 1930. There is also an undocumented report from Lake Chauncy, Westborough, but we have not seen specimens from that area. The White Crappie has always been an uncommon species in Massachusetts, but it appears to have continuously reproduced in this small area of the state since its introduction.

NOTES. The White Crappie is known to hybridize with the Black Crappie.

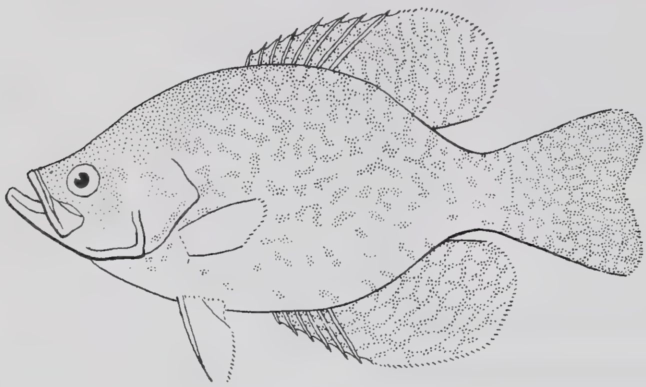
REFERENCES. Goodson 1966 (general biology); O'Brien et al. 1986, Wright and O'Brien 1984 (feeding), Mugford 1969 (Lake Chauncy).

Black Crappie

Introduced

Pomoxis nigromaculatus (Lesueur 1829)

PLATE 58

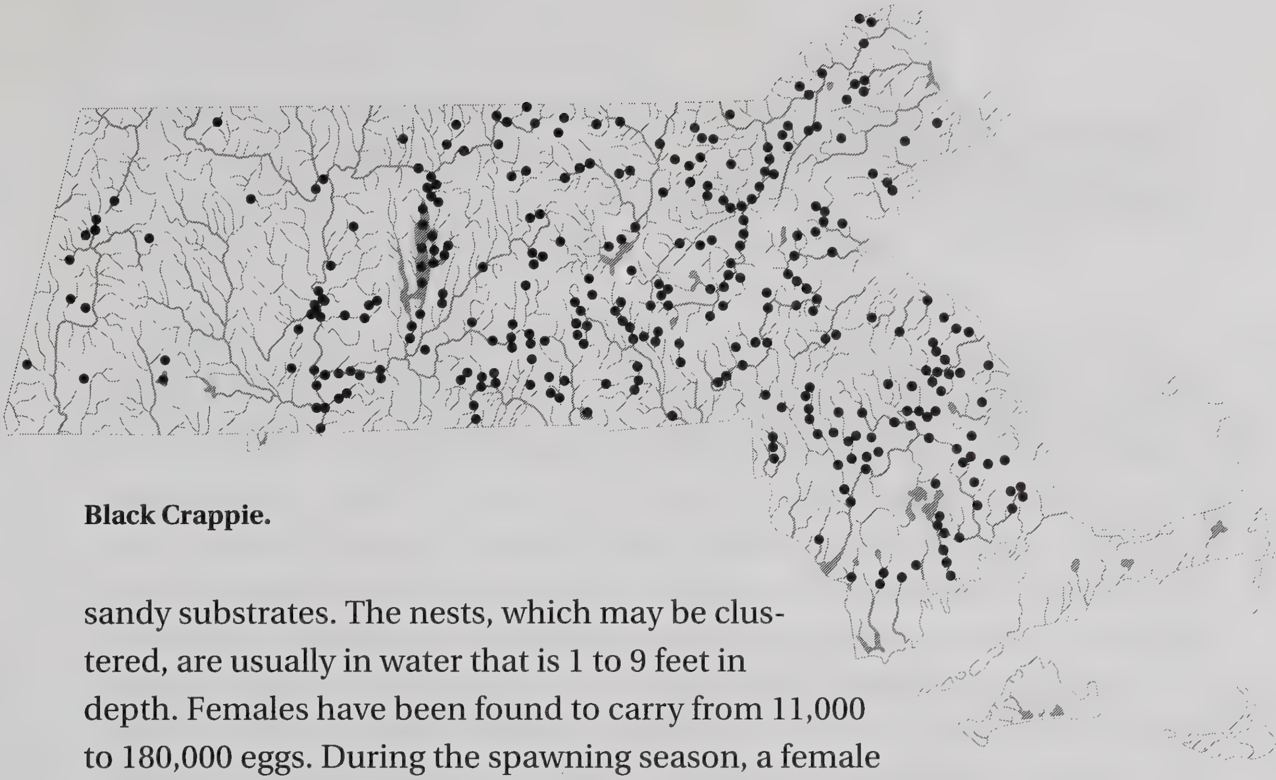


IDENTIFICATION. Black Crappies have compressed deep bodies, large mouths, sloping concave foreheads, usually seven or eight dorsal spines, and six or seven anal fin spines. The length of the base of the dorsal fin is approximately equal to the distance between the eye and the origin of the dorsal fin (see key Figure 3a). Black Crappies have a color pattern that is characterized by irregular mottling of dark spots and patches, while White Crappies have regular series of diffuse vertical bars along the sides of the body. During the breeding season, males often become much darker, almost black in color.

SELECTED COUNTS. D (VI)VII–VIII,15–18; A VI–VII,16–18; Scales 7/36–42/12; GR 27–29.

SIZE. Black Crappies are often encountered in the 8- to 12-inch TL range with larger individuals not uncommon. The current Massachusetts state record weighed 4 lbs. 10 oz. and was caught in Jakes Pond, Plymouth, in 1980.

NATURAL HISTORY. Black Crappies are found in rivers and streams, usually in quiet backwaters or deeper areas, and in ponds and lakes. They are often associated with cover, such as overhanging trees, submerged brush, docks, and aquatic vegetation. Black Crappies often form schools, but larger individuals are somewhat solitary. Spawning occurs from midspring to early summer when water temperatures are greater than 68°F. Shallow nests, 6 to 8 inches in diameter, are constructed by the males in areas with



Black Crappie.

sandy substrates. The nests, which may be clustered, are usually in water that is 1 to 9 feet in depth. Females have been found to carry from 11,000 to 180,000 eggs. During the spawning season, a female will spawn several times, laying eggs in the nests of a number of different males. Black Crappies forage primarily in midwater; large individuals feed almost entirely on other fishes. Small Black Crappies typically feed on aquatic invertebrates but will readily eat young fishes. Populations of stunted Black Crappies are common in locations lacking sufficient numbers of forage fishes. Black Crappies feed extensively during the twilight hours and at night, when they leave areas of cover and move into open water.

DISTRIBUTION AND ABUNDANCE. Black Crappies are native to a large area of the United States and southern Canada outside of New England. In Massachusetts, Black Crappies were first introduced in 1910 and were extensively stocked until 1940. They are common in many portions of the state, particularly in the central and eastern areas.

NOTES. Black Crappies, also known as "Calico Bass," are a popular game fish in many parts of the United States. The larger Black Crappies that are angled in Massachusetts typically come from large waterbodies, such as the Quabbin Reservoir and Onota and Quinsigamond lakes. Black Crappies hybridize with White Crappies.

REFERENCES. Goodson 1966 (general biology); Hanson and Qadri 1984 (diet); Keast 1968 (trophic biology).

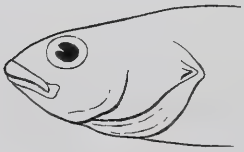
Perch Family

Percidae

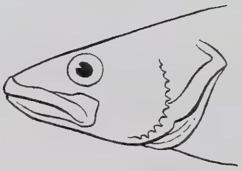
The perch family is found in the temperate freshwaters of the Northern Hemisphere. These spiny-rayed fishes are placed in nine genera with about 165 species. The American members can be divided into three groups (tribes): the perch group, Percini, which contains the Yellow Perch; the tribe Luciopercini, which is represented locally by the introduced Walleye; and the darters, Etheostomatini, which are found only in North America. There are over 145 darter species, with some species still undescribed. Many darters inhabit limited geographic areas and are listed as threatened or endangered. The controversy over the possible extinction of the Snail Darter, *Percina tanasi,* during construction of the Tellico Dam in Tennessee brought this group of fishes to the attention of the world. Most darters are colorful. In contrast, the two species found in Massachusetts are somewhat drab and do not exhibit the yellows, reds, greens, and blues so common in many other darter species.

REFERENCES. Collette et al. 1977 (biology); Collette and Banarescu 1977 (systematics, zoogeography); Kuehne and Barbour 1983, Page 1983 (reviews), Page 1985 (reproduction); Hokanson 1977 (temperature requirements).

Key to Massachusetts Perches and Darters

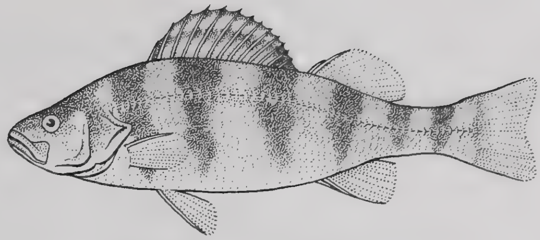


1a. Mouth small, maxilla reaching only front margin of eye. Darters. Go to 3.

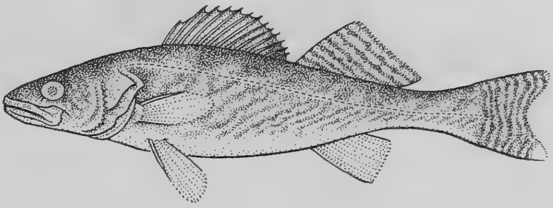


1b. Mouth large, maxilla extending to midpoint of eye or beyond. Go to 2.

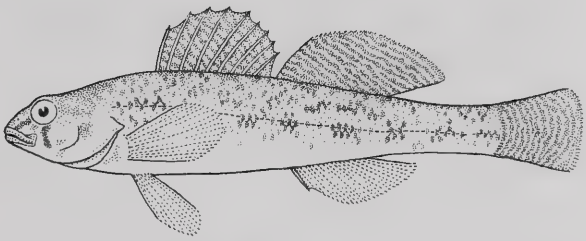
2a. Anal fin with 6 to 8 soft rays; teeth in lower jaw all of approximately equal height. Yellow Perch, *Perca flavescens*, page 272, Plate 66.



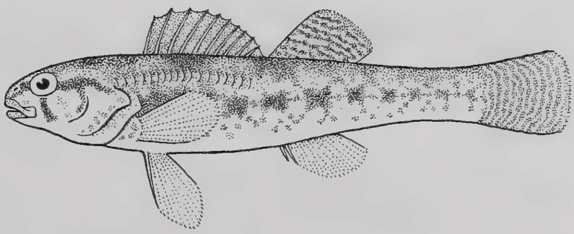
2b. Anal fin with 12 to 13 soft rays; typically two canine teeth, much larger than surrounding teeth, at anterior tip of lower jaw. Walleye, *Stizostedion vitreum*, page 274.



3a. Complete lateral line along midline of body; anal fin with 1 thin spine. Tessellated Darter, *Etheostoma olmstedi*, page 270, Plate 68.



3b. Incomplete lateral line placed high on body, end about midbody; anal fin with 2 thin spines. Swamp Darter, *Etheostoma fusiforme*, page 268, Plate 67.

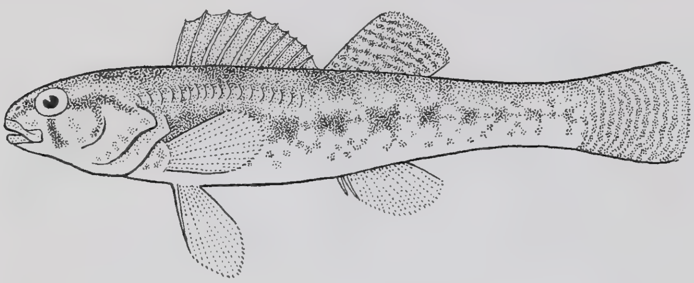


Swamp Darter

Native

Etheostoma fusiforme (Girard 1854)

PLATE 67

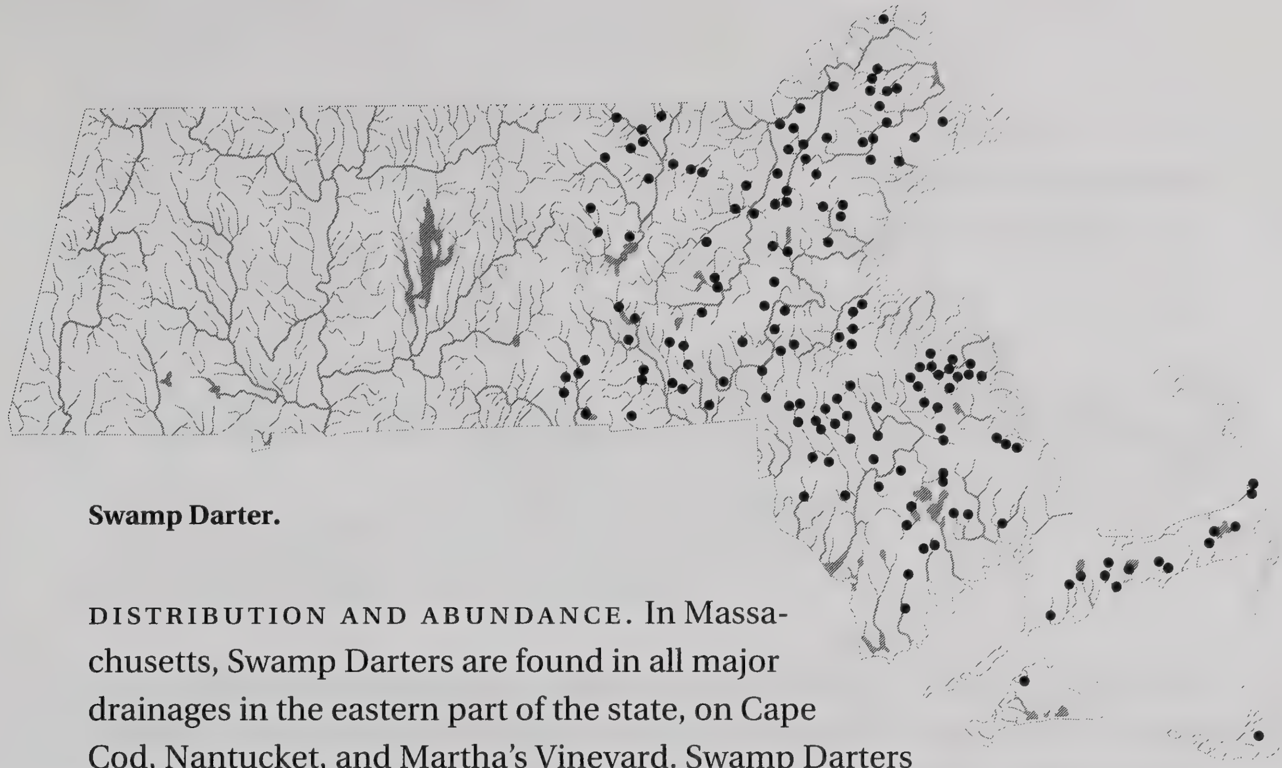


IDENTIFICATION. Swamp Darters have an incomplete lateral line that curves upward within three scales of the first dorsal fin and two anal spines. The body is brownish tan with about 10 dark-brown blotches that often merge into a continuous band along the midside and a small spot at the base of the tail. Overall coloration varies; fishes from weedy and tannic waters are quite dark, while those from sandy-bottomed clear ponds are somewhat lighter in color.

SELECTED COUNTS. D IX–XI,8–13; A II,5–10; Scales 3/51–54/7–10; GR 7–8.

SIZE. Adults range from 1 to 2 inches TL. The largest Massachusetts specimen that we have measured is 47 mm SL.

NATURAL HISTORY. Swamp Darters typically inhabit still or slow-flowing water where vegetation is abundant over mud and detritus bottoms. On Cape Cod and the Islands, however, they are found in clear-water ponds with only moderate vegetation. In Massachusetts, Swamp Darters probably spawn between mid-April and mid-May. Aquarium observations show that male darters court females by mounting them and making contact with their pelvic fins. If the female accepts a male, she leads him into aquatic vegetation where eggs are laid, one at a time, and fertilized on the plants. Eggs hatch in 8 to 10 days, and the young reach adult size by fall. It is believed that most Swamp Darters breed only once and die before their second breeding season. Swamp Darters often rest on aquatic vegetation and dart out to capture small aquatic organisms. Copepods seem to be their most common prey.



Swamp Darter.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, Swamp Darters are found in all major drainages in the eastern part of the state, on Cape Cod, Nantucket, and Martha's Vineyard. Swamp Darters are still common in many areas of eastern Massachusetts. Their overall distribution, however, has been reduced due to development of the large eastern cities and towns. The Nantucket population in Gibbs Pond was presumed extirpated in 1935, but it still persists today, with small numbers of specimens being found in 1956, 1981, 1987, and 1995. The Martha's Vineyard populations, although never reported previously, are common in Seths and Old House ponds.

NOTES. The Swamp Darter was originally described from tributaries of the Charles River near Framingham, Massachusetts, by C. Girard in 1854. The Cape Cod and Nantucket populations were thought to be distinct and were named as subspecies called *metae-gadi* (Cape Cod) and *insulae* (island) by C. Hubbs and M. Cannon in 1935. However, studies by B.B. Collette show that these populations do not deserve subspecific rank.

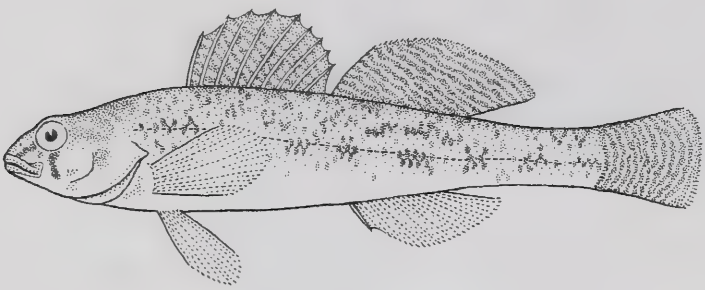
REFERENCES. Collette 1962 (systematics, distribution, life history); Hubbs and Cannon 1935 (systematics and description of Cape Cod and Nantucket populations); Schmidt and Whitworth 1979 (distribution, New England).

Tessellated Darter

Etheostoma olmstedi Storer 1842

Native

PLATE 68

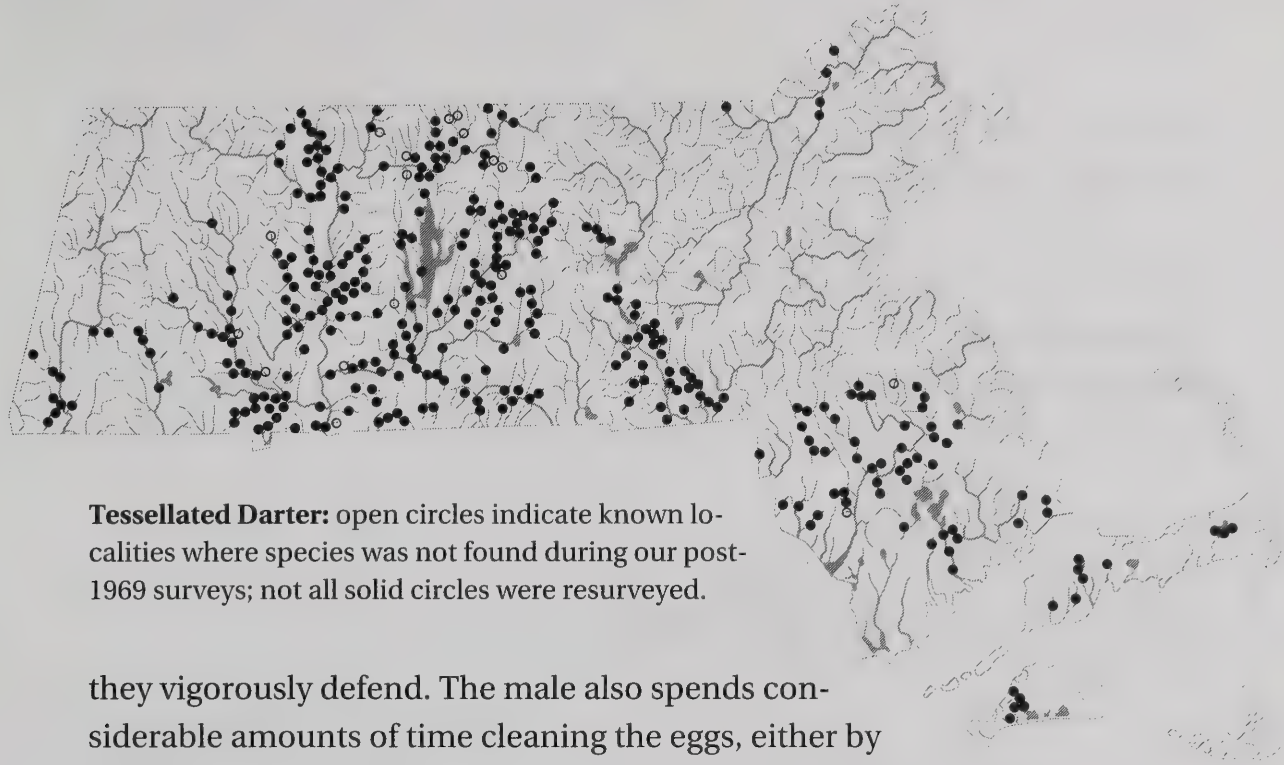


IDENTIFICATION. Tessellated Darters have a continuous lateral line along the midbody that does not arch upward, and they have a single anal spine. Nonbreeding Tessellated Darters are colored sandy-tan with several dark saddle-like marks and 9 to 10 dusky, lateral spots that often suggest the letters x, y, or z. Males usually have a dark blotch on the membrane between the first and second dorsal spines, become quite black, and develop swollen white tips on the pelvic fins when breeding.

SELECTED COUNTS. D XIII–XVI, 12–15; A I,7–8; Scales 4–6/42–48/6–9; GR 7–9.

SIZE. Adults are usually 2 to 3 inches TL. Raney and Lachner (1943) reported an 88 mm SL specimen from Massachusetts, and we have collected a few specimens over 4 inches TL (83 mm SL).

NATURAL HISTORY. Tessellated Darters prefer moving water and, unlike Swamp Darters, are seldom found in lakes or ponds. This darter frequents areas with rubble, sand, or mud bottoms that usually have some vegetation. They often sit motionless, propped up on their pelvic fins, on the bottom or on rocks and then make abrupt, quick darts when feeding or disturbed. Underwater objects, usually rocks or logs, are required for spawning. In early spring, a male selects and cleans a nest site on the underside of an object and then attracts a female. He leads the female to the nest site, and they spawn while hanging upside down under the object. A male will spawn several times with one or more females, until a large cluster of eggs is deposited. After egg-laying, males are solely responsible for the eggs, which



Tessellated Darter: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

they vigorously defend. The male also spends considerable amounts of time cleaning the eggs, either by fanning them with his tail or moving over them with his pelvic fins. After the eggs hatch, the young remain in the spawning area until they are about 1.5 inches TL. Males tend to grow faster and larger than females, and this size difference relates to their ability to defend the nest site. This species is short-lived, and most individuals die after their third summer, although a few survive into their fourth winter. Tessellated Darters feed mainly on the larvae of midges and other flies; however, they may switch to other food, such as caddisflies, later in the season.

DISTRIBUTION AND ABUNDANCE. In Massachusetts, this darter is common in most of the Connecticut and Blackstone river basins, in the southeastern parts of the state, and on Martha's Vineyard. It is rare in the northeast drainages, where only a few specimens have been found in the Merrimack River Drainage. This darter is absent from the Hoosic, upper Deerfield, Charles, and Nantucket drainages.

NOTES. In Massachusetts, this species has often been mistakenly called the "Johnny Darter." The true Johnny Darter, *E. nigrum,* is widespread outside of New England. The Tessellated Darter was originally described in 1842 from the Connecticut River near Hartford by D.H. Storer, an early Massachusetts ichthyologist.

REFERENCES. Atz 1940 (reproduction); Chapleau and Pageau 1985 (systematics); Cole 1967 (systematics and distribution); Constantz 1985 (behav-

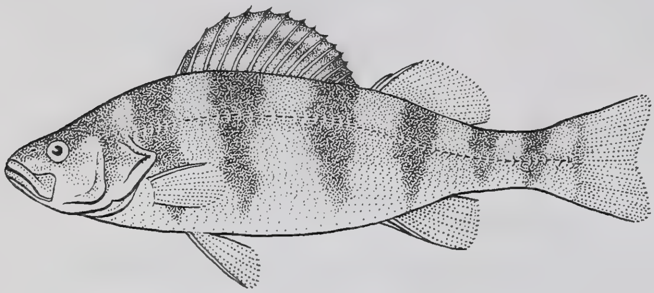
ior); Raney and Lachner 1943 (age and growth); Layzer and Reed 1978 (food, age, growth); Tsai 1972 (life history).

Yellow Perch

Native

Perca flavescens (Mitchill 1814)

PLATE 66

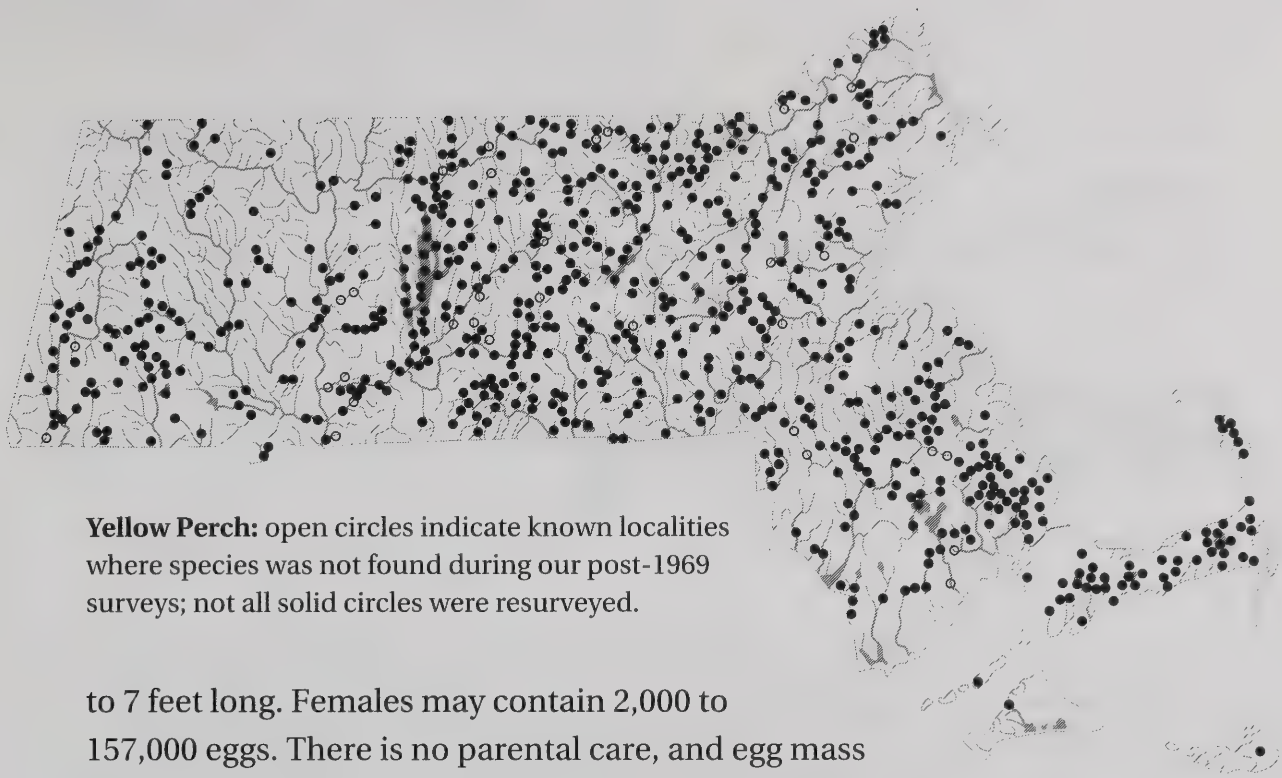


IDENTIFICATION. Yellow Perch have a short anal fin (six to eight rays) and lack canine teeth in the jaws. The first dorsal fin membrane has a dusky blotch between the last four spines, and the pelvic and anal fins of mature adults are brilliant red-orange. Small young are more silvery, while juveniles are overall green, without red on lower fins.

SELECTED COUNTS. D XII–XV+I,13–15; A II,7–8; Scales 6–8/53–64/13–14; GR 19–23.

SIZE. Most Yellow Perch taken by local anglers are 8 to 12 inches TL, and any specimen in excess of 12 inches and weighing over 1 pound would be considered large. The Massachusetts state record is a 2-pound, 12-ounce Yellow Perch from South Watuppa Pond in 1979.

NATURAL HISTORY. Schools of Yellow Perch commonly occur in both clear and weedy areas of lakes and ponds and in the slow-moving parts of larger streams and rivers. Young inhabit weedy shallows, while adults prefer rock ledges or submerged bars in deeper waters. Spawning occurs at night in shallow weedy areas during early April and May, when water temperatures are between 44° and 54°F. Gravid females are attended by as many as 15 to 25 males. Males fertilize the eggs as they are deposited by females over logs and vegetation. The eggs are released in strings that are cemented together in zigzag gelatinous bands that are several inches wide and up



Yellow Perch: open circles indicate known localities where species was not found during our post-1969 surveys; not all solid circles were resurveyed.

to 7 feet long. Females may contain 2,000 to 157,000 eggs. There is no parental care, and egg mass mortality can be high as a result of predation, wind-wave action, or low-water conditions. Young hatch in two to three weeks, depending upon the water temperature. Growth is variable, but a length of 8 inches TL can be expected in three years. If overpopulation occurs, stunted adults seldom exceed 6 inches TL. Yellow Perch are diurnal carnivores, feeding on small aquatic insects, crustaceans, and small fishes. They are commonly found in schools and are active year-round.

DISTRIBUTION AND ABUNDANCE. Yellow Perch are distributed statewide in Massachusetts, where it is a common warmwater species.

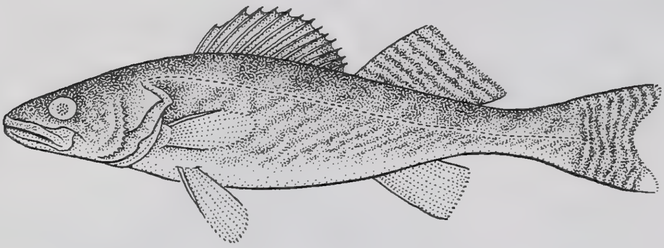
NOTES. Color variants of Yellow Perch, including some with an overall blue wash, have been found in Massachusetts and elsewhere. Since Yellow Perch are active year-round, including the winter, they are popularly pursued by ice-anglers.

REFERENCES. Ney 1978 (review); Tsai and Gibson 1971 (fecundity); Scott 1955, Muncy 1962, Thorpe 1977, Helfman 1979 (behavior); Jobes 1952, Mansueti 1964b, Brazo et al. 1975, Ney and Smith 1975 (growth); Tharratt 1959, Siefert 1972, Keast 1977a (food); Hart 1933 (blue color); Burdick et al. 1957 (oxygen requirements); Clady 1976 (effects of wind and temperature).

Walleye

Introduced

Stizostedion vitreum (Mitchill 1818)

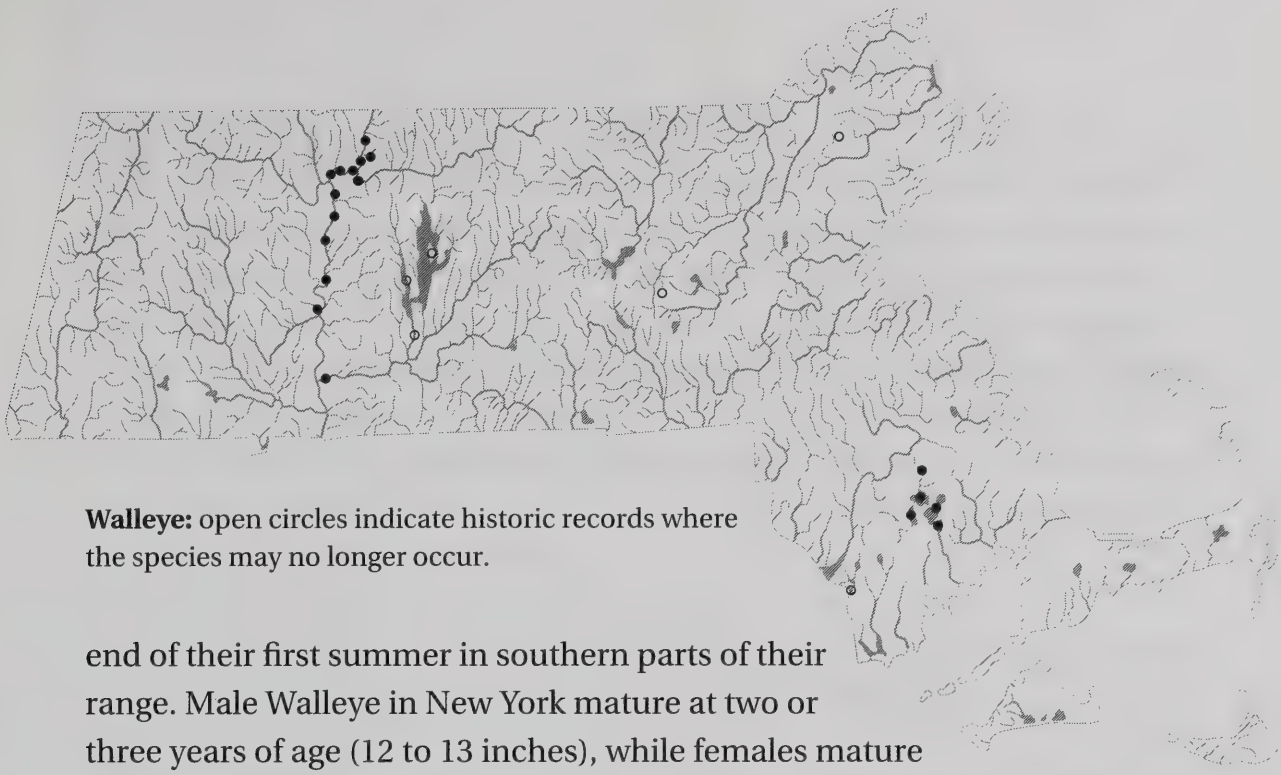


IDENTIFICATION. Walleye have two well-separated dorsal fins, two poorly developed anal spines, two large canine teeth, and 12 to 13 anal rays. Walleye are olive-brown to gray-yellow dorsally, shading to yellow-silvery on the sides, and creamy-white ventrally. A dark blotch is present at the base of the pectoral fin and on the posterior membrane of the first dorsal fin. The edge of the anal fin and the tip of the lower caudal lobe are white.

SELECTED COUNTS. D XIII–XIV+I,19–21; A II,12–14; Scales 12/83–104/15; GR 10–13.

SIZE. Walleye are the largest members of the perch family. Typical adults range from 13 to 22 inches and 1 to 5 pounds. The Massachusetts state record, from Quabbin Reservoir in 1975, weighed 11 pounds.

NATURAL HISTORY. Walleye are a coolwater species, inhabiting both lakes and larger rivers. They are nocturnally active, feeding along gravel bars in rivers or along rocky shoals in lakes. Walleye generally prefer firm bottom substrates with gravel or bedrock. Similar to Yellow Perch, Walleye are active year-round. Walleye spawn in the spring following ice-out, when water temperatures approach 40°F. Males are nonterritorial, nests are not built, and parental care is not provided. Spawning occurs at night when one or two females and up to six males will move into the shallows and broadcast eggs and sperm over the substrate. Females carry between 23,000 and 615,000 eggs. Eggs deposited in crevices are protected from predation and hatch in 12 to 25 days, depending on water temperature. Within two weeks after hatching, young Walleye disperse into the shallows of open water. Growth is rapid, and juveniles attain a length of 3.5 to 12 inches TL by the



Walleye: open circles indicate historic records where the species may no longer occur.

end of their first summer in southern parts of their range. Male Walleye in New York mature at two or three years of age (12 to 13 inches), while females mature at ages four or five (about 17 inches). The diet of Walleye shifts rapidly as they grow. Juveniles feed on planktonic crustaceans, gradually switching to aquatic insects and then to small fishes after they reach 3 inches or so. Adult Walleye are voracious predators that feed predominantly on other fishes. They can become highly cannibalistic in the absence of readily available small fish prey.

DISTRIBUTION AND ABUNDANCE. Walleye are native to a large area of central North America. They were first introduced into the Connecticut River in the early 1900s from Lake Champlain stock. From 1953 to 1960, stocks from western Lake Erie were introduced into several Massachusetts waterbodies, including Quabbin Reservoir, Lake Chauncy in Westborough, and Assawompsett Pond in Lakeville. In the 1980s, experimental stocking of a Lake Oneida strain in the Taunton River Drainage was carried out. Today, Walleye are found in the northern portion of the Connecticut River as well as in the Assawompsett Pond system of the Taunton (Nemasket) River Drainage. Remnant Walleye from earlier stocking programs may still be found in Quabbin Reservoir; however, their ability to reproduce may have been limited by this reservoir's characteristically acidic waters.

NOTES. A subspecies of Walleye, the Blue-pike, *S. v. glaucum*, was formerly abundant in Lake Erie but is now thought to be extinct. Overfishing and gene mixing, coupled with the effects of accelerated eutrophication, are probable reasons for the loss of this subspecies.

REFERENCES. Ney 1978, Colby et al. 1979 (review); Ryder and Kerr 1978 (feeding); Robins 1970 (bibliography); Kelso and Ward 1972 (unexploited population); Campbell 1987 (Blue-pike status); Groen and Schroeder 1978 (water level management); Nickum 1978 (culture); Serns 1978 (size limits); Carlander and Whitney 1961, Wolfert 1977 (age, growth); Forney 1974 (predation); Raney and Lachner 1942, Eschmeyer 1950 (life history).

Jack Family

Carangidae

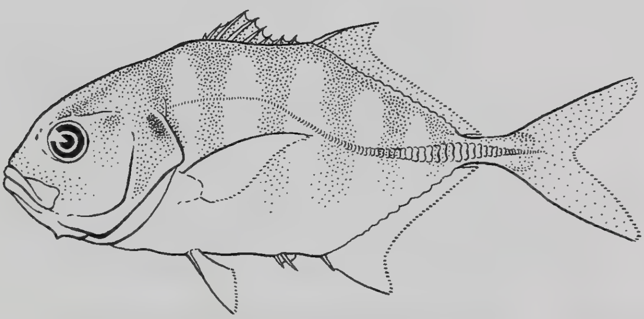
The carangids, also known as jacks, pompano, or scad, are found worldwide in temperate to tropical marine waters. About 140 species are known but only 13 enter Massachusetts marine waters. Only one species, the Crevalle Jack, enters Massachusetts freshwaters. Jacks are important game and food fishes wherever they are found.

REFERENCES. Bigelow and Schroeder 1953 (local marine species); Laroche et al. 1984 (development); Smith-Vaniz 1984 (relationships).

Crevalle Jack

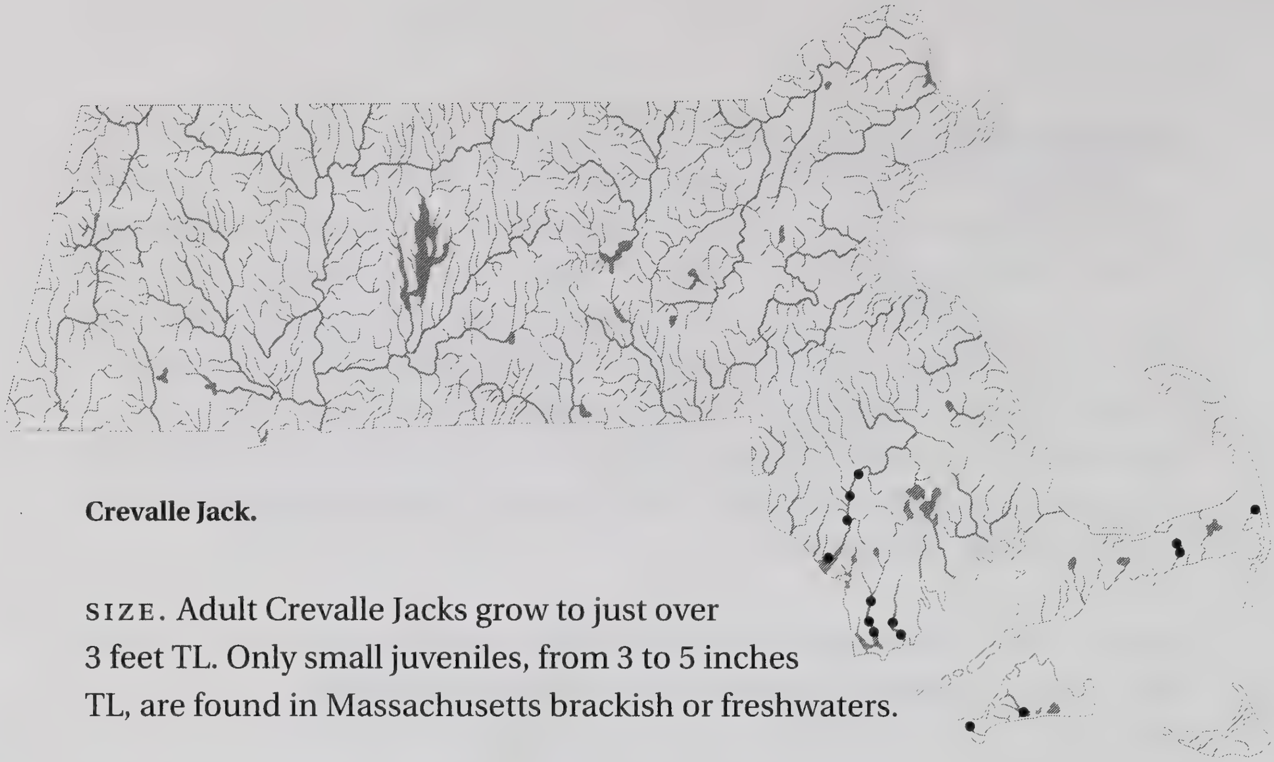
Native

Caranx hippos (Linnaeus 1766)



IDENTIFICATION. Crevalle Jacks can be distinguished from all other perch-like Massachusetts freshwater fishes by the expanded, spinous scutes along the posterior straight section of the lateral line. This is the only jack found in local freshwater; other *Caranx* species, which closely resemble this species, are sometimes found in estuaries. Positive identification of specimens from estuaries may require review of the marine references at the end of this account. The deep-bodied juveniles are silvery with dark, vertical bands along the sides. Adults lack the bars, become less deep-bodied, and have a more rounded forehead.

SELECTED COUNTS. D VII–VIII,20; A II,17–18.



Crevalle Jack.

SIZE. Adult Crevalle Jacks grow to just over 3 feet TL. Only small juveniles, from 3 to 5 inches TL, are found in Massachusetts brackish or freshwaters.

NATURAL HISTORY. Crevalle Jacks are a marine species, but, in some parts of their range, juveniles enter brackish to freshwater. In Massachusetts, these young fishes are most commonly found between mid-June and mid-October. Sometimes, large numbers of juveniles enter rivers; a mass mortality was noted in the Slocums River, Dartmouth, in 1969. The salinity at the site of the die-off was almost fresh (0.5–1.4 parts per thousand); however, these southern fishes probably died after being exposed to cold spring water from a nearby brook. In June 1980, we collected a juvenile (60 mm SL) at the head of the Westport River, which is seven miles from the river's mouth. When collected, this fish was healthy and had eaten a 24 mm SL Mummichog just before it was caught. Adult Crevalle Jacks are common open-water predators.

DISTRIBUTION. Crevalle Jacks are found from Nova Scotia to Uruguay but are most common south of Cape Cod. In Massachusetts, juveniles have been found in the Buzzards Bay and Taunton drainages and might be expected in the Cape Cod, Narragansett Bay, and Islands drainages.

REFERENCES. Berry and Smith-Vaniz 1977 (identification, distribution); Hoff 1971 (mortality, Slocums River).

American Sole Family

Achiridae

All of the flatfishes are linked together by the asymmetrical placement of the eyes and their compressed bodies. In addition, flatfishes are born with normal eyes; that is, with an eye on each side of the head. However, during development and metamorphosis into the juvenile form, one eye migrates over the head and toward the other so that both eyes end up on one side of the body. The eyes almost always move to one side or the other, giving the flatfish either a right-eyed or left-eyed appearance that is usually characteristic of each family. The soles are right-eyed flounders that lack pectoral fins and have the blind side pelvic fin united to the anal fin. The Achiridae, consisting of about 30 species, are found only in the New World. Many of these, including the one Massachusetts species, enter freshwater. The true soles should not be confused with other flatfishes that are often marketed as "sole" in the United States. In New England, these latter fishes are members of the Pleuronectidae, of which the Winter Flounder, *Pseudopleuronectes americanus,* is marketed as "lemon sole" and the Witch Flounder, *Glyptocephalus cynoglossus,* is sold as "gray sole."

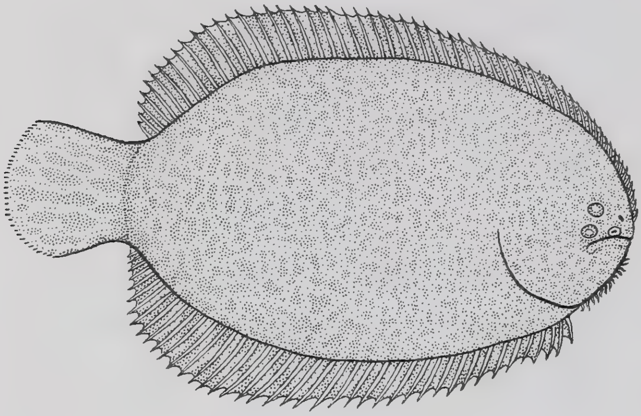
REFERENCES. Bigelow and Schroeder 1953 (local marine species); Hensley and Ahlstrom 1984, Cooper and Chapleau 1998 (relationships).

Hogchoker

Native

Trinectes maculatus (Bloch and Schneider 1801)

PLATE 55

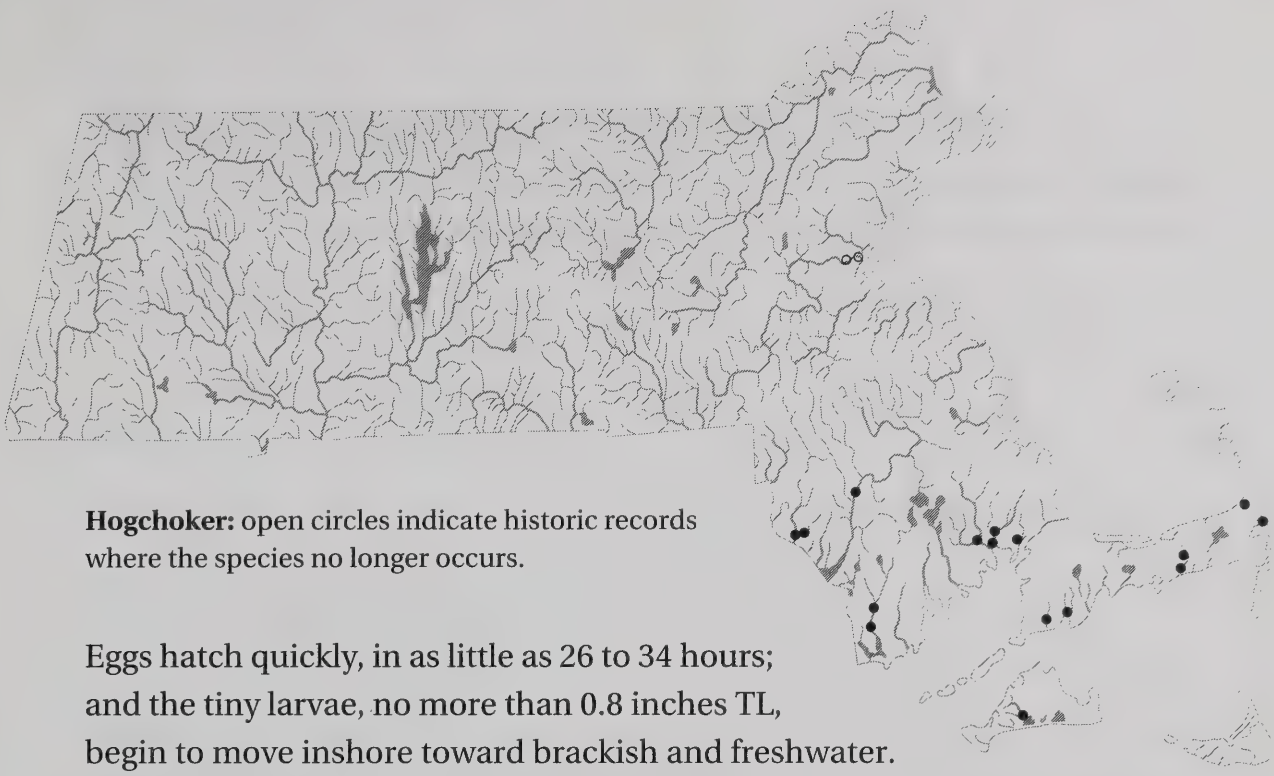


IDENTIFICATION. Hogchokers have both eyes on the right side, lack pectoral fins, and have oval bodies. Their dorsal fin reaches the tip of the snout, and they have a curved mouth surrounded by many fleshy tabs, or papillae. The eyed side is mottled brown-olive, often with 10 or so vertical lines on the body. The blind side is either creamy white or spotted with medium-sized dark dots. Several marine flatfishes may invade the upper estuary but should not be confused with this species because the Hogchoker is the only local, right-eyed flatfish that lacks pectoral fins.

SELECTED COUNTS. D 50–56; A 36–42; Scales 66–75.

SIZE. Hogchokers are small flatfishes that seldom grow more than 6 inches TL. The young-of-the-year, most commonly found in freshwater, range up to one inch TL (25 mm SL).

NATURAL HISTORY. Hogchokers spend their lives on the bottom of estuaries and coastal streams. Their body shape and color provide efficient camouflage, and small specimens are often overlooked, even in a net, because they look like small leaves. Hogchokers spawn from May to October with peak spawning occurring at maximum day length and maximum water temperature. The small eggs (about 1 mm) are spawned in the lower estuary in areas of high salinity. A large, 6-inch female may contain 50,000 eggs.



Hogchoker: open circles indicate historic records where the species no longer occurs.

Eggs hatch quickly, in as little as 26 to 34 hours; and the tiny larvae, no more than 0.8 inches TL, begin to move inshore toward brackish and freshwater. It is thought that Hogchokers use the tidal wedge for upstream transport. The young-of-the-year spend their first fall and winter in brackish to freshwaters, where they find both protection from predators and abundant food. During their second summer, they move downstream but not as far as the spawning areas. Hogchokers mature during their third summer and live up to six years. Each season, adults move inshore during the winter and return to the spawning area in the spring. Hogchokers feed on worms, crustaceans, and other benthic invertebrates.

DISTRIBUTION AND ABUNDANCE. Massachusetts is the northernmost part of the range of the Hogchoker. In Massachusetts, they are most common in the southeast, where young have been recorded from brackish and freshwaters of almost all the south-flowing drainages. This species is rare north of Cape Cod; however, L. Agassiz procured a number from the mouth of the Charles River in 1874. Bigelow and Schroeder (1953) noted that they had not seen a Hogchoker record from north of the Cape since Agassiz's report. In October 1980, we collected a juvenile in the freshwaters of Rock Creek, Orleans, a tributary to Cape Cod Bay; there are also recent published records of Hogchokers from marine waters near the Pilgrim Power Plant, Plymouth.

NOTES. This fish's strange name originates from colonial times. Apparently, when hogs fed on discarded fishes, they had difficulty swallowing this fish because of its hard, rough scales.

REFERENCES. Bigelow and Schroeder 1953 (origin of name); Dovel et al. 1969 (life history); Koski 1978 (life history); Lawton et al. 1984 (Plymouth records); Martin and Drewry 1978 (review and development).

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Pages	Plates	Date	Vol.	Art.	Pages
1–44	1–8	1853	5	(4)	49–92
44–90	9–16	1853	5	(8)	122–168
91–130	17–23	1855	5	(12)	257–296
131–194	24–29	1858	5	(7)	309–372
195–240	30–35	1863	8	(15)	389–434
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Appendix 2. Distribution Table of Massachusetts Inland Fishes

BASIN	Hudson				Connecticut						Thames		Merrimack				Massachusetts Bay								Southern New England								
DRAINAGE	Hoosic	Kinderhook	Bashbish	Housatonic	Farmington	Westfield	Deerfield	Connecticut	Millers	Chicopee	Quinebaug	French	Nashua	Concord	Shawsheen	Merrimack	Parker	Ipswich	North Shore	Mystic	Charles	Neponset	Weymouth-Weir	South Shore	Blackstone	Ten Mile	Narragansett	Mount Hope	Taunton	Buzzards Bay	Cape Cod	Martha's Vinyard	Nantucket
State Drainage Code	11	12	13	21	31	32	33	34	35	36	41	42	81	82	83	84	91	92	93	71	72	73	74	94	51	52	53	61	62	95	96	97a	97b
American brook lamprey																																	
Sea lamprey														H															H				
Shortnose sturgeon																													H		H		
Atlantic sturgeon																					H												
Bowfin																																	
American eel																																	
Blueback herring																																	
Alewife																																	
American shad														H				H?	H?		H	H			H								
Gizzard shad																																	
Bay anchovy																			N														
Goldfish																																	
Lake chub																																	
Common carp																																	
Eastern silvery minnow																																	
Golden shiner																																	
Bridle shiner																																	
Mimic shiner																																	
Common shiner																		H			H												
Spottail shiner																																	
Northern redbelly dace																																	
Bluntnose minnow																																	
Fathead minnow																																	
Blacknose dace																																	
Longnose dace														H															H?				
Rudd																																	
Creek chub																																	
Fallfish	L?																				H										H		

BASIN	Hudson				Connecticut						Thames		Merrimack				Massachusetts Bay								Southern New England								
DRAINAGE	Hoosic	Kinderhook	Bashbish	Housatonic	Farmington	Westfield	Deerfield	Connecticut	Millers	Chicopee	Quinebaug	French	Nashua	Concord	Shawsheen	Merrimack	Parker	Ipswich	North Shore	Mystic	Charles	Neponset	Weymouth-Weir	South Shore	Blackstone	Ten Mile	Narragansett	Mount Hope	Taunton	Buzzards Bay	Cape Cod	Martha's Vinyard	Nantucket
State Drainage Code	11	12	13	21	31	32	33	34	35	36	41	42	81	82	83	84	91	92	93	71	72	73	74	94	51	52	53	61	62	95	96	97a	97b
Longnose sucker						H		H		H																							
White sucker																																	
Creek chubsucker																			H														
White catfish				L								L										L				L				L			
Yellow bullhead																																	
Brown bullhead																																I?	
Channel catfish																		L															
Tadpole madtom																																	
Margined madtom																																	
Redfin pickerel																																	
Chain pickerel																																I?	I?
Northern pike																																	
Tiger muskellunge																																	
Central mudminnow																																	
Rainbow smelt																																	
Rainbow trout																																	
Atlantic salmon																																	
Brown trout																																	
Brook trout																																	S
Lake trout																																	
Trout-perch	X			X																													
Burbot				H																													
Atlantic tomcod																																	
Atlantic needlefish																																	
Sheepshead minnow																																	
Banded killifish																																	
Mummichog																																	
Spotfin killifish																																	
Rainwater killifish																																	

BASIN	Hudson				Connecticut						Thames		Merrimack				Massachusetts Bay								Southern New England								
DRAINAGE	Hoosic	Kinderhook	Bashbish	Housatonic	Farmington	Westfield	Deerfield	Connecticut	Millers	Chicopee	Quinebaug	French	Nashua	Concord	Shawsheen	Merrimack	Parker	Ipswich	North Shore	Mystic	Charles	Neponset	Weymouth-Weir	South Shore	Blackstone	Ten Mile	Narragansett	Mount Hope	Taunton	Buzzards Bay	Cape Cod	Martha's Vinyard	Nantucket
State Drainage Code	11	12	13	21	31	32	33	34	35	36	41	42	81	82	83	84	91	92	93	71	72	73	74	94	51	52	53	61	62	95	96	97a	97b
Atlantic silverside																																	
Inland silverside																																	
Striped mullet																																	
Fourspine stickleback																		?															
Threespine stickleback																		?									?	?	?				
Blackspotted stickleback																					H												
Ninespine stickleback																		?			H												
Northern pipefish																																	
Slimy sculpin																H																	
White perch																																	
Striped bass																																	
Rock bass																			L														
Banded sunfish						H																										I?	
Redbreast sunfish																																	
Green sunfish																																	
Pumpkinseed																																	I?
Bluegill																																I?	
Smallmouth bass																																	
Largemouth bass																																	
White crappie																																	
Black crappie																																	
Swamp darter																																	
Tessellated darter																																	
Yellow perch																																	
Walleye									L	L				L				L										L					
Crevalle jack																																	
Hogchoker																					H												

= Native
= Introduced, reproducing
= Stocked, non-reproducing
H= Historical, probably not extant in drainage
L= Literature record
X= Extirpated from drainage

Appendix 3. Glossary

Acid precipitation Rain or snow with a characteristically low pH (acidic).

Adipose fin, dorsal A small fleshy fin along the dorsal midline before the caudal fin.

Aestivation A form of inactivity similar in some ways to hibernation.

Ammocoete A larval lamprey.

Amphipods Small shrimp-like crustaceans.

Anadromous Fishes that live in marine waters and migrate into freshwater to spawn; see catadromous.

Anal fin The ventral median fin, located behind the anus.

Anoxic Lacking oxygen.

Anus The vent or terminal opening of the intestine.

Asymmetrical Structures shaped differently on left or right planes of body (not symmetrical).

Axillary projection (or scale) An elongate scale at the base of the pelvic fin.

Barbel Fleshy projection containing sensory organs; sometimes long and pointed (as in catfish) and located on the snout, jaws, chin, or lips.

Benthic Associated with the the substrate or bottom.

Buccal cavity The mouth or oral cavity.

Catadromous Fishes that live in freshwater and migrate to salt water to spawn; see anadromous.

Caudal fin The posterior median fin, often called the tail fin.

Caudal peduncle The part of the body that supports the tail, starting at the end of the anal fin.

Cheek The side of the head below and slightly behind the eye.

Chironomids Nonbiting midges (flies, Chironomidae).

Cladocerans A group of small, flea-like crustaceans (zooplankton).

Cloacal appendage Tissue adjacent to the cloaca, enlarged, often pointed.

Compressed Laterally compressed, flattened side to side, as in the body of many fishes.

Copepods A group of small shrimplike crustaceans (zooplankton).

Crepuscular Most active at dawn or dusk.

Crustaceans A large group of invertebrates, including crabs, shrimp, crayfish, and copepods.

Ctenoid scale A scale with spines on posterior edge.

Cycloid scale A scale with a smooth edge.

Deep-bodied A body relatively deep in relation to length.

Depauperate Refers to a fauna comprised of few species.

Diadromous Fishes that migrate between saltwater and freshwater (anadromous and catadromous).

Diatoms A group of pelagic microscopic algae.

Dorsal fin The dorsal median fin that may be divided into two parts and supported by soft rays or a combination of spiny and soft rays.

Endemic Native and restricted to an area.

Exotic Not native, introduced to an area by humans.

Extinction The complete and permanent loss of a taxon from its total range.

Extirpated Refers to a taxon (species, subspecies, etc.)

lost from parts of its total range.

Falcate Usually referring to fins that are notably concave or sickle-shaped on the trailing edge.

Fauna Refers to animals that occur in a given region.

Fecundity The reproductive potential of a female based on the number of eggs produced annually.

Filamentous Pertaining to long, threadlike structures.

Fin rays Structures that support the fin; always paired, usually segmented and branched but may be spine-like in some fishes.

Fin spines Bony structures that support fins; usually pointed and stiff, never segmented or branched.

Frenum A band of tissue linking the upper lip to the snout.

Gas bladder See swim bladder.

Gill filaments The posterior projections of the gill arch used in respiration.

Gill rakers The anterior projection of the gill arch (see Figure 8); often used to filter or process food.

Gonads The reproductive organs: ovaries or testes.

Gular plate A bony element on the ventral part of the head as found in Bowfin.

Heterocercal A caudal or tail fin in which the vertebrae extend into and support the upper tail lobe.

Homocercal A symmetrical tail in which the vertebrae are not turned into the upper lobe.

Interorbit (interorbital) The area between the eyes, measured betwen the bony rims of the eyes.

Introduced (alien, exotic, or non-native) Transported by humans into an area in which it did not historically occur.

Larva The early life stage of a fish, usually with a different body shape and behavior.

Lateral line Pores along the body where neuro-receptors penetrate scales, bony elements, or skin.

Leptocephalus The larval stage of eel-like fishes.

Maxilla The posterior upper jaw bone in fishes (see Figure 8).

Midges See Chironomids.

Milt Sperm and associated fluid, often cloudy when released into water.

Nape The part of the back from the posterior end of the head to the origin of the dorsal fin.

Nasal Pertaining to the nose.

Native Species known to occur naturally in an area, not introduced by humans.

Nocturnal Pertaining to activity at night.

Opercle Part of a major set of bones on the side of the head that protects the gills, sometimes called a gill cover or operculum (see Figure 8).

Oral disc The mouth structure of a lamprey. Larval lamprey have a fleshy oral hood covering the area.

Oral jaws The front or typical jaws in contrast to the internal or pharyngeal jaws. Consists of the premaxilla, maxilla, and dentary.

Origin Used in reference to structures; for example, the beginning or anterior-most starting point of a fin.

Papilla Small fleshy dermal structures that are often knoblike.

Parr Juvenile salmon or trout, often with dark vertical bars on body (parr marks).

Pectoral fins Paired fins associated with pectoral girdle or "shoulder bones," can be low or high on body.

Pelvic axillary process A modified scale located in the axil of the pelvic fin.

Pelvic fins A set of paired fins (also see pectoral fin) that are highly variable in shape and position but usually found ventrally, posterior to pectoral fins.

Peritoneum The lining of the abdominal cavity.

Pharyngeal Pertaining to the throat in the area of the branchial basket or gill arches.

Pleat Structure of soft tissue usually found in rows, ridges, or grooves as on the lips of suckers.

Predorsal The area anterior to the dorsal fin origin.

Premaxilla The anterior bones of the upper oral jaw (see Figure 8).

Preoperculum Part of a major set of bones on the side of the head that protects the gills, sometimes called gill cover.

Primary Refers to the groups of fishes that live only in freshwater.

Procurrent rays Small rays anterior to median fins, most evident before the ventral and dorsal edge of the caudal fin.

Protrusible jaw Jaw in which the structure of bones and muscles allow the jaw to protrude from the snout.

Pyloric caeca Out-pocketings along the digestive tract.

Redd A nest created in gravel substrate by salmon and trout.

Refugium An area where a species may survive adverse conditions.

Ripe Gravid or containing developed eggs or sperm; ready to spawn.

Salinity The amount or concentration of salt in water, usually expressed in parts per thousand.

Secondary Refers to a group of fishes that regularly move between freshwater and saltwater.

Serrated A structure with a sawlike edge; usually a fin spine.

SL Standard Length, a method of measuring fishes (see Figure 8).

Slab-sided Describes a fish with a flat-sided body, which is compressed laterally.

Snout The area of the head anterior to the eyes.

Soft rays Supporting elements in all fins, usually branched and always segmented unlike fin spines. Also see fin rays.

Spiral valve Specialized internal structures in the intestine.

Swim bladder A bladderlike structure found dorsally in the abdominal cavity; often filled with gas (sometimes called gas bladder) and used for buoyancy control, respiration, and gas exchange.

TL Total Length, a method of measuring fishes (see Figure 8).

Vascularized Tissue containing many small blood vessels.

Viscera The internal organs, such as heart, stomach, liver, and kidneys.

Vomer Bone found along midline of the roof of the mouth; often with teeth.

Zoogeography The study of the geographical distribution of animals.

Zooplankton The portion of the plankton composed of small animals rather than plants.

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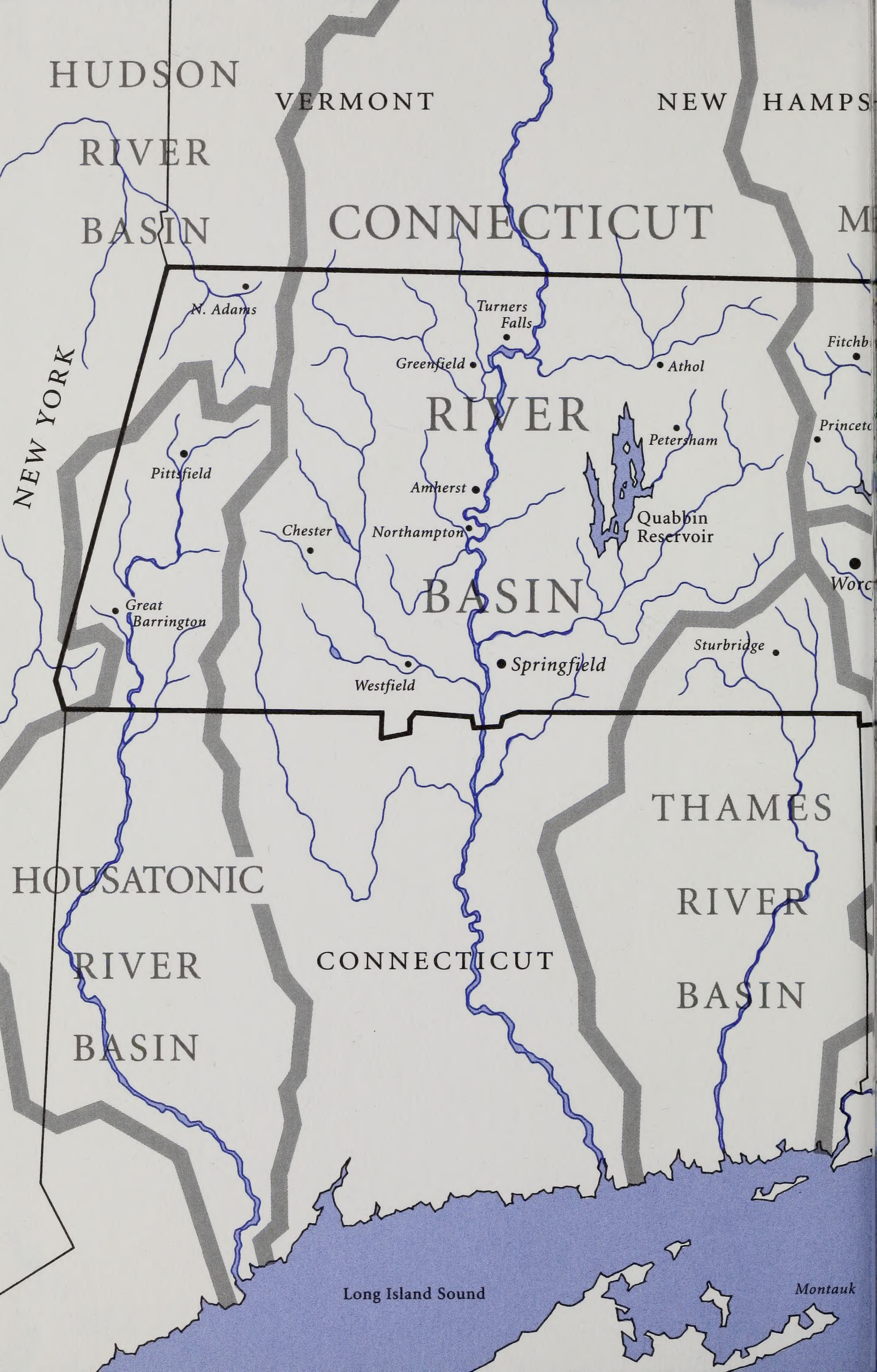
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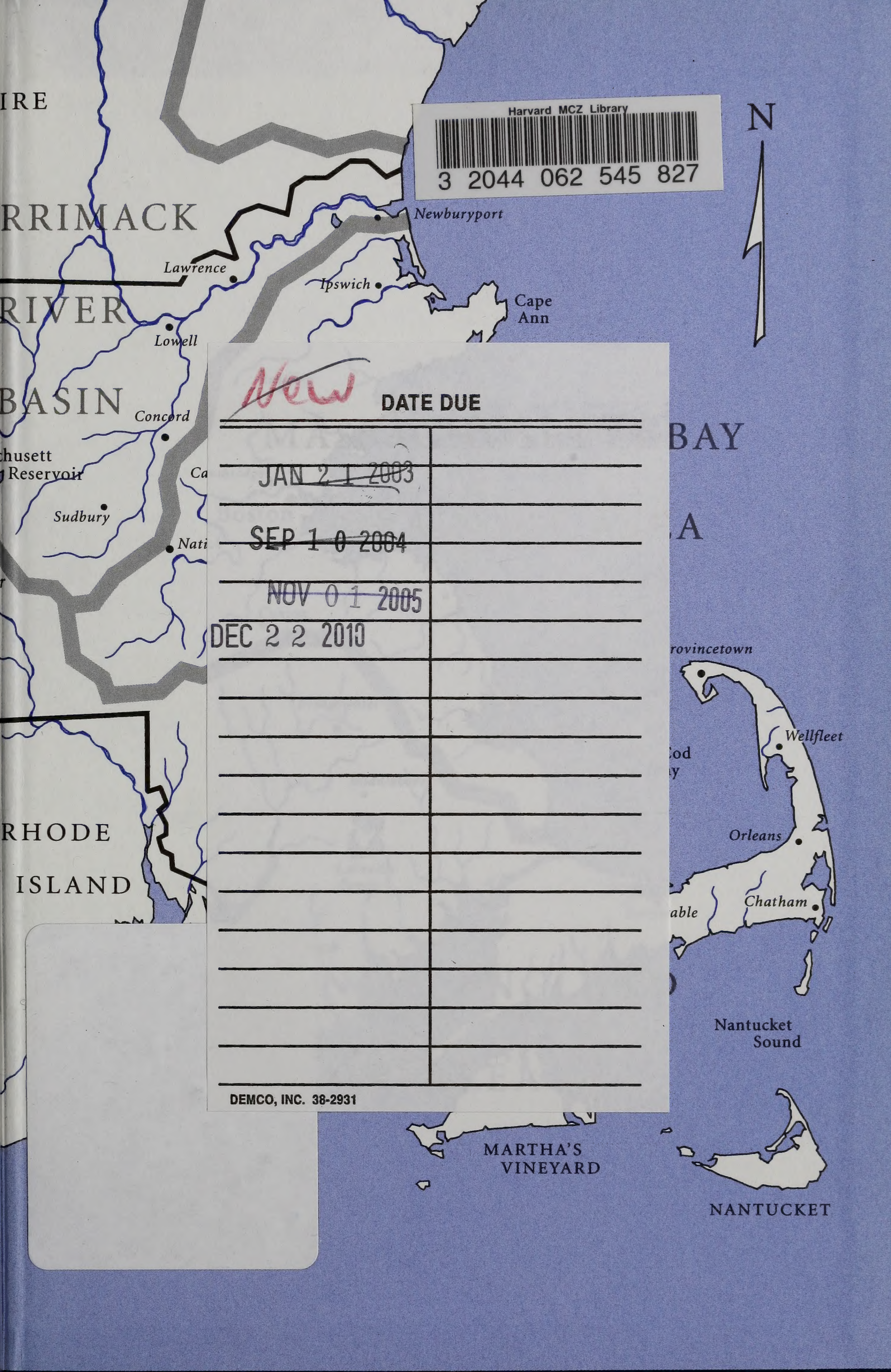
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